TRANSACTIONS

OF

THE AMERICAN SOCIETY

OF

HEATING AND VENTILATING ENGINEERS

VOL. XV.

FIFTEENTH ANNUAL MEETING

NEW YORK, JANUARY 19-21, 1909

SUMMER MEETING

INDIANAPOLIS, IND., JULY 15-16, 1909

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THE AMERICAN SOCIETY OF HEATING AND VENTILATING ENGINEERS

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CXCV.

THE AMERICAN SOCIETY

OF

HEATING AND VENTILATING ENGINEERS.

FIFTEENTH ANNUAL MEETING.

New York City, N. Y., January 19, 20, 21, 1909.

PROCEEDINGS.

First Day—Afternoon Session.

(Tuesday, January 19, 1909.)

The meeting was called to order by President James Mackay, at 3 o'clock P.M.

President Mackay: I want to appoint a reception committee, whose duties will be to receive every one coming in at the door, see that they are provided with literature and that they register and take a number. I appoint on that committee Messrs. J. A. Donnelly, G. B. England, and August Kehm.

The Secretary announced the names of the following parties elected to membership since the last meeting:

Louis K. Berman	Member
M. M. Cochran	"
Chas. A. Gillham	"
Joseph G. Hayes	"
John H. Kassa	"
Geo. W. Knight	"

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Arthur S. Leitch.....Member
W. W. Macon..... "
Peter F. Maginn..... "
Sidney R. Sheldon..... "
Lawrence C. Soule..... "
Frank H. Stevens..... "
John H. Textorius..... "
Jacob O. Trautwein ..... "
James R. Wade..... "

The Secretary then called the roll, and stated that a quorum was present.

Mr. Chew moved the reading of the minutes of the previous meeting be dispensed with. Carried.

President Mackay then read the following address:

PRESIDENT'S ADDRESS.

Once more we gather to promote the aims and objects for which our organization was formed, namely, advancement of the arts and sciences connected with heating and ventilating, and as your presiding officer it is my privilege, as well as pleasure, to open this, our fifteenth, annual meeting.

It is hoped and expected that the proceedings of the several sessions of this meeting will prove as valuable and interesting as are the records of those meetings which have passed into history.

During the year just closed your officers and Board of Directors have endeavored to execute your instructions and perform their duties, as outlined by the Constitution, in a dignified and creditable manner.

The Society has made gratifying progress numerically, and from an engineering standpoint our attainments are everywhere recognized as most creditable.

Agreeable to and under control of our Constitution one chapter of the Society is in active existence. It is composed of earnest members of this, the parent body, all of whom attend every monthly meeting of the chapter, take active part in all discussions, work with enthusiasm for the good of their chosen calling in general, and for the American Society of Heating and Ventilating Engineers in particular.

Our friends of the press have accorded our organization due credit for the good we have accomplished, and have given us that generous share of publicity which is beneficial, not only to us, but to all who are interested in our work.

I congratulate the Society upon the interest and activity shown in our work during the past year. I fully realize that we are all busy people, and yet I know that all have contributed, in some measure, toward our growth. Personally, I thank each and every member for the thought bestowed, the time given and the labor expended in our behalf.

The search of committees contributes largely to the success and merit of our work. Credit is due to all our committees for their labor and for the excellent manner in which they have discharged their duties.

The Society is to be commended for the position it has taken upon the subject of proper and necessary ventilation, and for what it has done toward promoting the same, through legislative enactment and otherwise. On the whole, we have accomplished much in the past, are in a healthy state of efficiency at the present time, and the future is laden with promise.

We are living in an age of specialization and progress; when ripe experience, practical knowledge and sound theory are paramount. The school house, the mail box and the telephone are crowding the frontier. The wolf and the wilderness are retreating. Are we keeping well abreast of this swinging forward march?

When we realize that in no line of human activity, save one, has greater material advancement been made during recent years than in the industries that are based chiefly upon the arts and sciences which we study and promote, this query is natural, and suggests vigilant consideration of all our affairs from every possible angle, so that we may wisely improve our methods and enhance the value of our labors.

The published volumes of our Proceedings, thirteen of which are issued and one is now due, mark our progress and indicate our growth. These volumes constitute our literature, and in a broad sense are our greatest asset, for they tell the world what we are, what we have accomplished and what we hope to be. As a reference library they are important and are consulted as authority.

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But a study of these volumes will show that certain subjects have been similarly discussed more than once without eliciting in the later repetitions anything of fresh engineering value. Therefore it would seem wise to review our literature so as to avoid useless reiterations.

It behooves us also to keep our records up to a rigorous scientific standard. And, with these two points in view, it has been suggested that your Society devote a future meeting to a review of our past publications. I concur in this suggestion, and recommend that your next President and Board of Governors arrange for such a meeting.

We have in our possession a number of engineering publications, acquired in exchange for ours. These volumes form the nucleus of a library which should be extended, catalogued and made more available for the general use of our members. I recommend that action be taken with this end in view.

Improvement of the Society's facilities will result in individual benefit. Therefore we should all take greater interest in studying the requirements necessary to promote our work.

Let us by the character of our attainments attract to our membership those of the profession whose association with us will be the most beneficial in promoting good.

Engineers in the field of heating and ventilating have more especially devoted their efforts toward inventing and designing improvements upon the older types of apparatus or appliances used in the better known applications of the art.

Innovations have been made, but examples are comparatively few.

There are untrodden paths in the broad field of engineering effort which await exploration.

We should know more about the use and possibilities of superheated steam.

Simple and more efficient means are required for purifying the air and ventilating all the rooms of our buildings.

Another desirable possibility is a simple and inexpensive apparatus for cooling the air of our rooms during the summer months as many degrees as we now raise its temperature in the winter season.

But improvement in present practice is of equal importance. Let us discourage guess-work and rule of thumb methods and

encourage more scientific designing and installation of heating and ventilating work.

Our aim should be for excellence in theory and practice, bearing in mind as a precept the oft-quoted words attributed to Emerson, "If a man can write a better book, preach a better sermon, or make a better mouse-trap than his neighbors, though he build his house in the woods, the world will make a beaten path to his door."

The President's address was received with applause.

President Mackay: The grim reaper, Death, has visited our ranks during the year, and two of our fellows have been called to that home from whence no traveller returns. We mourn their loss.

Then, you have all heard of the death of Alfred R. Wolff, an engineer of very high standing in his profession. While not a member of our organization he was in sympathy with our work, and was one of our friends, who was always willing to aid us and did a great deal to bring the profession on a high plane to give it recognition among the affairs of men. His many works throughout this country are a lasting monument to his memory. It seems fitting we should take some notice of this. He has done a great deal for our profession.

Secretary Mackay then read his report, as follows:

SECRETARY'S REPORT.

The American Society of Heating and Ventilating Engineers:

Gentlemen: Your Secretary would report an increase in membership during the past year.

At the last annual meeting our membership was composed of 1 Honorary Member, 278 Members, 27 Associates, and 17 Juniors, or a total of 323 members of all grades.

By a unanimous vote of the members present at the last annual meeting, Mr. Charles W. Newton, of Baltimore, Md., a former Charter Member of the Society, was elected an Honorary Member. During the year we have added 32 Members, 3 Associates, and 2 Juniors to our roll. Three Members were dropped from the roll for non-payment of dues, 3 Members and 2 Associates resigned, 1 Member, 2 Associates and 1 Junior failed to qualify, and we had two deaths in our ranks during

the past year, Mr. Enoch Rutzler, who became a member in 1901, died February 29, 1908, and Mr. Harry J. Ott, who became a Junior Member in 1906, died September 25, 1908.

Our present membership is 2 Honorary Members, 302 Members, 26 Associates, and 17 Juniors, a total of 347 Members of all grades, a net increase of 24.

The financial affairs of the Society are in a good condition, at the last annual meeting there was a balance in the hands of the Treasurer of $2,044.86. During the past year we have received from all sources $3,928.93, which with the balance on hand made a total of $5,973.79.

The total expenditure amounted to $4,025.84, leaving a balance in the hands of the Treasurer of $1,947.95.

There is owing to the Society from members for dues and Proceedings and from newly elected members for initiation fee and dues, $1,215.00. This with the balance on hand amounts to $3,162.95. All bills have been paid except those in connection with this meeting, the Secretary's account for December and the bill for the 1907 Proceedings which have just been received from the printers and are ready to be sent out to the members.

The members dropped from the roll during the past year owed the Society $80.00.

The 1908 Proceedings are being edited, and will be placed in the printer's hands as quickly as possible.

At the request of your Secretary, the constitution was amended so that he as well as the Treasurer would furnish a bond, and his bond for $1,000.00 has been filed with the Board of Governors.

The Secretary's expenses for the year, including stenographer, clerk hire, rent of post-office box, certificates of membership, expenses in connection with the summer meeting, postage, express, telegraphs, telephone, office rent, etc., amounted to $1,121.49, being $68.99 less than the previous year.

The Society held a summer meeting at Niagara Falls, July 24, 25, 1908, which was successful in every way.

Most of the papers for the present meeting were received late, but all were printed and sent to the members eleven days ago, together with the reports of three important committees presented for consideration at this meeting.

The Secretary has fifteen applications for membership which were received too late to be included in the last ballot. This will ensure a ballot being sent out as soon after this meeting as possible, and those having applications to send in should do so at once, so that they may be placed on this ballot.

It will be interesting to the members to know that when I was first elected Secretary ten years ago, the Society had 119 members, an increase of fifty per cent. from the time of its organization five years before.

During the ten years that I have been Secretary the Society has increased three hundred per cent.

Your Secretary has received $1,900.00 in salaries for the past ten years, or an average of $190.00 per year.

Respectfully submitted,

WM. M. MACKAY,
Secretary.

The Secretary then read the report of the Treasurer, as follows:

TREASURER'S REPORT.

NEW YORK, January 19, 1909.

Balance on hand, January 21, 1908		$2,044.86
Cash received:		
Dues	$2,882.77	
Initiation fees	570.00	
Proceedings	293.75	
Electrotypes	120.40	
Pin badges	24.00	
Interest on deposits	38.01	3,928.93
		$5,973.79
Disbursements:		
J. J. Little & Co., printers	$1,294.01	
Schoen & Kellerman, printers	348.08	
W. M. Mackay, Secretary's account	1,022.54	
W. M. Mackay, Secretary's salary	500.00	
Harold Godfrey, reporting meeting	220.00	
Atlas Engraving Co	144.92	
Wm. Kent, editing 1907 Proceedings	125.00	
Carried forward	$3,654.55	

Brought forward	$3,654.55	$5,973.79
Remington machine and stand	90.00	
Williams Engraving Co., electros	36.28	
Poates Engraving Co., electros	70.50	
Expenses, annual dinner	25.70	
United Eng. Society Meeting Rooms	85.00	
John Frick, pin badges	30.00	
Natl. Fire Prot. Asso. dues	15.00	
U. G. Scollay, Treas., account	6.20	
Empire Surety Co., bond	6.00	
Empire Mfg. Co., number buttons	4.14	
People's Trust Co., exchange	2.47	4,025.84
Balance on hand		$1,947.95

Respectfully submitted,

U. G. SCOLLAY,

Treasurer.

On motion of Mr. Barwick the report was accepted as read and placed on file.

The report of the Board of Governors was then read by the Secretary.

REPORT OF THE BOARD OF GOVERNORS.

NEW YORK, January 19, 1909.

The American Society of Heating and Ventilating Engineers:

Gentlemen: Your Board of Governors met and organized on January 23, 1908, appointing committees on Finance, Membership and Publication, and an Executive Committee, as provided for in the Constitution.

The various committees have given careful attention to their duties, and the Board has met as often as was found necessary during the year.

A successful summer meeting was held at Niagara Falls, N. Y., on July 24, 25, 1908.

The Society has acquired membership in the National Fire Protection Association, receiving their publications, and has applied for recognition on their committees, and has also suggested the forming of a new committee on " Necessary Fire Protection

in Connection with the Installation and Operation of Heating and Ventilating Apparatus."

On request the question of members using the emblem of the Society on their stationery was considered, and it was decided that it should not be used except on the Society stationery, but that the different grades of membership were privileged to use the words: " Member, Associate Member, or Junior Member, The American Society of Heating and Ventilating Engineers " on their stationery should they desire to do so.

There is a continuous demand for back numbers of our Proceedings from colleges, libraries, and our own members.

We have on hand the following volumes:

Volume	I,	1895	Proceedings..	2	volumes
"	II,	1896	" ..	26	"
"	III,	1897	" ..	120	"
"	IV,	1898	" ..	140	"
"	V,	1899	" ..	111	"
"	VI,	1900	" ..	115	"
"	VII,	1901	" ..	140	"
"	VIII,	1902	" ..	102	"
"	IX,	1903	" ..	156	"
"	X,	1904	" ..	142	"
"	XI,	1905	" ..	162	"
"	XII,	1906	" ..	150	"

a total of 1,366 volumes, the value of which at our members' regular price is $6,830.00, or at their special price, $5,017.50.

Volume XIII, 1907, has been printed and bound, has just been received, and will be sent out to the members immediately after this meeting.

Volume XIV, 1908, is well in hand, and will be in the printer's hands at an early date.

These Proceedings are sold to our members at a stated price, with a reduction if six or more volumes are purchased at one time.

The Board would recommend the re-editing and printing of Volume I of the Proceedings in an edition of from 150 to 200 copies.

The Secretary has filed with the Board his bond for $1,000.00.

The Board has purchased for the use of the Secretary a

Remington typewriter and stand, and it will be necessary to purchase one or more book-cases to hold the Proceedings of our own and other Societies and other books sent in from time to time which form a library for the use of our members now in the office of the Secretary, accessible to members.

It has been brought to the attention of the Board that members and others have published papers, extracts from papers, and discussion of topics as having been presented before the Society, without obtaining its consent.

This is in direct violation of the condition under which the papers are accepted.

We now have a flagrant case of disregard for the Society's established rules in this respect where an advertising agent has violated our rules.

The Board has called attention to the violation, and has requested that the circulation of the pamphlet referred to above be stopped, and it would recommend that such steps be taken as may be necessary to protect the Society's interest in the matter.

The papers to be presented at this meeting were received late. One paper was received early in November, but as the others were not received until after December 20th, two of them in January, it was decided to print them at one time, and they were distributed to the members eleven days ago, as the extra expense of distributing the early paper was considered unnecessary.

The necessity of pointing out that there may be some mistakes in the papers and cuts, is on account of the hurried manner in which they had to be prepared owing to the disregard by the members of the Society's rules and their own convenience and benefit.

The Society has been criticised in the past regarding the care exercised by its officers over the acceptance and printing of the papers and their publication in our Proceedings, but the vigilance which would have positively protected the Society has been impossible owing to the short time that could be taken for this important work.

We feel that, regardless of the action of other societies in this matter which at times has been quoted, too much care cannot be exercised if we wish to maintain the high standard which

has always been aimed at. In connection with this matter we feel justified in quoting from the December, 1908, issue of the Journal of the "American Society of Mechanical Engineers."

Extract from the Report of the Publication Committee:

"The Committee has examined carefully all of the papers presented at the meetings of the Society with a view of passing upon their suitability for publication in the Transactions. In this work it has endeavored to maintain the dignity of the Transactions, and to this end has considered it its duty to omit any objectionable personalities that might be found in the papers or in the discussions of the same. It has also endeavored to omit portions of papers or discussions where this could be done without eliminating ideas or data.

"Proceeding in accordance with the above plan, the Committee has found it advisable to omit the publication of several papers, and in other cases has eliminated a considerable amount of matter from the text."

Extract from the Report of the Meetings Committee of the A. S. M. E.:

"As a natural result of the expansion of the Society's work, the numbers of papers submitted to your Committee for approval has very greatly increased, so that it becomes necessary to reject a considerable portion of those which are offered. We believe this condition is one on which the Society is to be congratulated. The aim should be to make our publications of such rank that it will be esteemed an honor by an engineer to have a paper accepted and published by our Society. This condition can only be brought about, however, if the number of papers offered continues materially in excess of the number which will be used, since it is only when such a surplus exists that proper selection becomes possible.

"The objection will doubtless be raised that it is a disappointment to an individual author if after spending much time in the preparation of a paper it is finally rejected by the Society. The answer to this objection is that the interests of the profession—of the Society as a whole—are more important than the interests of any individual. If our Society finds itself obliged to reject an offered paper, its author is at liberty to seek publication through other channels.

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"There are, however, certain papers which by reason of great length, or because they appeal only to some small branch of the profession would not be accepted by any Journal published by private enterprise, and are for the same reasons undesirable for our Society publications. We believe that certain papers of this class, where they contain material which would in some form be made available for record, can be treated in the way which has long been practiced by the Institution of Civil Engineers of Great Britain. That is, the paper as a whole can be filed in the Society's library for reference, and either its title only or some brief summary of the writer's conclusions and recommendations can be published in the Society's Journal.

"By proper adoption of such a policy, it should be possible for the Society to increase the number and variety of papers in its Transactions without increasing the bulk and expense of the volume."

Extract from the Proceedings of the Engineers' Society of Western Pennsylvania, incorporated 1880:

"All papers, on their acceptance by the Publication Committee, become the property of the Society, and it lies within the discretion of the committee to publish them in whole or in part."

The financial affairs of the Society are in a prosperous condition, and the membership is larger and more representative than ever before, with every indication of a large increase during the coming year.

We carry in stock at the office of the Secretary the Society emblem in the shape of a pin badge in solid gold and gold plated.

The furniture, effects and Proceedings of the Society are carefully housed in the office of the Secretary.

Respectfully submitted,

JAS. MACKAY, Chairman,
J. D. HOFFMAN, Vice-Chairman,
B. F. STANGLAND,
FRANK K. CHEW,
R. C. CARPENTER,
AUG. KEHM,
C. B. J. SNYDER,
JOHN F. HALE,
W. M. MACKAY, Secretary.

President Mackay: The standing committees are Compulsory Legislation, Standards and Tests. Are there any reports?

Secretary Mackay: I do not believe any members of any of these committees are present, and I have received no reports from them. The only thing I have is from Professor Hoffman, who writes under date of January 16th, from Indianapolis, that he met Mr. Weinshank and arranged for a report of the Committee on Tests. (Letter read.)

President Mackay: We have the following special committees: Hot Water Heating Data, Steam Heating Data, Sizes of Steam and Return Mains, Fan Blast Data, Data on Surfaces in Heating Boilers, Data on Air Washers, Relative Corrosion of Wrought Iron and Steel Pipes and Furnace Heating Data.

Mr. J. J. Blackmore, Chairman, presented the following:

REPORT OF COMMITTEE FOR COLLECTING DATA ON STEAM HEATING FOR SMALL BUILDINGS.

January 19, 1909.

The Committee decided to divide the work of collection of data into three divisions, as follows:

The Boiler, from the manufacturer's viewpoint and from the viewpoint of the engineer who purchased it for installation, the figuring of radiation for loss of heat, and the practice for installation of flow and return pipes.

Inquiry among the manufacturers shows that a good deal of progress has been made toward standardizing, but that a good deal yet remains to be done.

Grate Surface.

The size of grate for a given size boiler, or the proportion of grate surface to the capacity of the boiler, varies so much, that inquiry was made on this point, and no satisfaction could be obtained, but a comparison of six of the leading sectional types is here made, to show the proportion in this respect.

Boiler.	A.	B.	C.	D.	E.	F.
Rated capacity	800	800	775	750	750	750
Sq. inches of grate.....	616	740	648	528	630	648
Ratio of grate to 100 ft. of capacity, sq. ins.	77	92.5	83.6	70.4	84.	86.2

The question of how much coal should or could be burned per sq. foot of grate surface does not appear to have been con-

sidered by many of the makers, and your Committee could only learn of three manufacturers who had done anything to determine how much should be burned per square foot of grate in small boilers.

If we take a boiler of 800 feet of steam radiator capacity, it will have to transmit 216,000 B. T. U., assuming that each square foot of radiation gives off 270 B. T. U. per square foot per hour.

If we assume that 10,000 B. T. U. is the thermal value of a pound of anthracite coal that can be usefully transmitted in a house heating plant, we must burn 21.6 pounds of coal per hour, when the heater is running at its maximum capacity—and for a boiler of 750 feet we would burn 20.25 pounds of coal. This gives a rate of combustion of 5.1 lbs. per square foot for Boiler A, 4.2 lbs for B, 4.65 lbs. for C, 5.63 lbs. for D, 4.4 lbs. for E, and 4.5 lbs. for F.

This variation is so great that it would seem that the manufacturers have not yet adopted a standard.

Heating Surface.

The question of heating surface in a boiler seems to be an unknown quantity, and inquiry among the manufacturers does not produce much information on the subject. Some of the makers have experimented to determine the amount of heat transmitted per square foot of boiler surface, but your Committee could not ascertain that any data were gathered as a result of such tests. Your Committee did see some calculated data on this subject, but could not ascertain that anyone used them or was guided by them. The proportion of fire surface to flue surface has had some attention from the manufacturers, but no definite proportion is stated except by one maker, who claims 60 per cent. of fire surface and 40 per cent. of flue surface.

Very few manufacturers give the amount of heating surface in small boilers, nor do they give any rule by which their boilers can be measured. For the purpose of getting information from the various engineers who make a business of installing small heating plants, a series of questions was sent to members of the Society, and others, a copy of which is attached to this Report.

The Committee did not depend entirely on these question blanks, but inquired personally, in different parts of the country, with a view to gathering information.

To the question: "Do you depend on manufacturers' ratings?" 89 per cent. of the replies are "Yes," 7 per cent. reply "No," and 4 per cent. "Not without checking."

To the question: "What percentage do you add to the radiation, to provide for loss by boiler and piping?" 70 per cent. of the replies say: "25 per cent. should be added," 10 per cent. reply: "30 per cent. should be added," 10 per cent. say "18 per cent. should be added," and 10 per cent. reply that they figure the actual amount of the loss, and so add it to the radiation.

To the question: "What additional do you figure as a factor of safety?" 70 per cent. reply "25 per cent."—10 per cent. reply "30 per cent."—10 per cent. reply "15 per cent."—and 10 per cent. reply "10 per cent."

To the question: "Do you consider grate surface a factor in sizing up the boiler?" 80 per cent. reply "Yes" and 20 per cent. reply "No."

To the question: "How many inches of grate do you figure to 100 ft. of surface?" very little could be learned, and nearly all replies to the question left this blank.

To the question: "Do you consider the shape a factor?" 82 per cent. reply "Yes" and 18 per cent. "No." Some preferred round fire pots, and some square or oblong—but not enough information could be gathered to put these into exact percentages.

To the question: "Do you examine the chimney of a building to determine the draft you will get?" 90 per cent. reply "Yes" and 10 per cent. reply "No." Inquiry on this point shows that the examination is made only as to its size, and to see that it is properly built, and that no other stove or heater goes into the same flue.

The Committee could not learn that any attempt was made to test chimney flues for velocity by anyone engaged in the work of erecting small steam plants.

To the question: "Do you figure on any rate of combustion per sq. ft. of grate per hour?" 86 per cent. reply "No," 14 per cent. give rates of combustion of 5 lbs., 7 lbs. and 8 lbs. per sq.

ft. of grate per hour. The Committee do not consider the high rates of 7 or 8 lbs. should be taken as reliable in such small plants.

To the question: "What steam pressure do you figure on as a basis?" 60 per cent. reply "2 lbs."—20 per cent. reply "3 lbs."—10 per cent. reply "5 lbs."—10 per cent. reply "1 lb."

QUESTIONS ON FIGURING RADIATION.

In answering these questions, most of the replies state that they use some standard rule, and the following are mentioned quite freely: Baldwin, Mills, Carpenter, Snow and Wolff. The Committee received very few replies that indicated that the cubical contents only of a building were figured on.

The replies indicated that all northern rooms were provided with 10 per cent. or 15 per cent. extra radiation.

Answers in regard to indirect radiation: 86 per cent. added 50 per cent. to 60 per cent. to the direct radiation which would be needed for the same room. 14 per cent. of the replies figured on the exact amount needed to provide for the air changes. No answers were received, nor information obtained that could be tabulated in regard to the best type of radiator to be used. The trade seemed to give them all about the same value.

Flow and Return Pipes.

In the answers received on this subject, none of the questions were replied to, but a large number of replies were received to the question: "How large a main pipe should be used for 1,000 square feet of radiation?" None were less than 3 in. some were 3½ in., and a few 4 in.—showing uniform practice within a reasonable range.

Your Committee found that nearly all work of installin small heating plants was done under what is classed as "competition work"; and the engineering features of such installations have been reduced to what might be called "rule of thumb" practice, guided by experience.

The fact that a very large number of plants are installed each year, and give excellent results, would indicate that the art has made good progress.

Your Committee regret that more data could not be collect

so as to give more detailed information as to the practice in all the States; but it is extremely difficult to get replies to questions sent by mail, and the Committee have submitted all they could collect.

The information obtained was from the following States: Massachusetts, Connecticut, New York, New Jersey, Pennsylvania, Ohio, Illinois, Indiana, Minnesota, Wisconsin, Montana, Washington, California, Missouri and Colorado; and it was obtained mostly from people actually engaged in the construction of such plants.

The Committee did not consider it part of their work to take data from standard works that can be referred to at any time: but rather to secure all possible information from parties engaged in the business.

All of which is respectfully submitted.

J. J. BLACKMORE,
JAMES A. DONNELLY,
GEORGE B. ENGLAND.

NEW YORK, November 21, 1908.

Questions prepared by the Committee appointed by The American Society of Heating and Ventilating Engineers to collect data on steam heating for small buildings.

Questions for gathering data on small steam boilers in plants of from 300 to 1,000 square feet.

1. Do you take the manufacturers' rating as a basis when figuring the size of boiler required?
2. What percentage do you figure in addition to the radiation for main flow and return pipes, risers, etc.?
3. What additional percentage do you figure as a measure of safety?
4. Do you consider the grate surface as a factor in sizing up the boiler?
5. If you consider the grate surface, how much do you allow for each one hundred feet of direct radiation?
6. Do you consider the shape of the grate a factor?
7. Do you examine the chimney of a building to determine the draft you will get?
8. Do you figure on any rate of combustion per square foot of grate per hour?
9. What steam pressure do you estimate on for your calculations?
10. Give method of obtaining necessary radiation.

Questions on the subject of radiation.

11. Give rule for wall exposure.
12. Give rule for glass exposure.

13. Give rule for ceiling exposure.
14. Give allowance for north, east, and west exposure.
15. Give rule for direct radiation.
16. Give rule for indirect radiation.
17. Give rule for direct-indirect radiation (or semi-direct radiation).
18. Give surface allowed for change of air (ventilation).
19. What height of radiator is the most effective?
20. What number of sections is the most effective?
21. State best position in room for radiator.
22. In connecting to riser, which is best for the long run, the steam or return?
23. Are pipe surfaces more efficient than cast iron?
24. How much more surface is needed on ceiling than at the floor?
25. What is the best form of connecting nipple?
26. Give rule or formulæ for test when weather is warmer than temperature mentioned in the contract.

Questions for the collection of data on size of steam and return mains on small steam heating plants.

The following questions refer to the size of steam and return pipes in small steam heating plants, and those not having a run to exceed 100 feet from the source of supply.

27. What is the maximum amount of Direct Radiation which you consider permissible where the steam and condensation in the mains flow in the same direction?
28. What is the maximum amount of Direct Radiation where the steam and condensation flow in opposite directions in horizontal pipes?
29. What is the maximum amount of Direct Radiation in (a) Up-Feed Steam Risers; (b) Down-Feed Steam Risers?
30. What is the maximum amount of Direct Radiation which is permissible to connect the return risers?
31. The maximum amount on Horizontal Dry Return Mains?
32. The maximum amount on Horizontal Wet Return Mains?
33. What are the amounts of Radiation which you consider the maximum for radiator connections upon one and two pipe systems?

President Mackay: Is there any discussion of this report? It will go into the hands of the Committee on Standards, but it is now before you for discussion.

Mr. Chew: I move the report of this committee be printed and distributed with the papers for the coming summer meeting for discussion at that meeting.

Mr. Barwick moved to amend, that the committee be continued.

Mr. Chew: I accept that. I think the original idea in the appointment of these various committees was to get conclusive information on the particular line of work the committee had

in charge, and I don't think there is any occasion for the men who have done the work to be discharged when they are familiar with it. I think that kind of work is creditable to the Society, and the Society will certainly accord to that committee the honor to which they are entitled for that work.

President Mackay: This report represents a great deal of labor and of thought and quite a little expense on the part of this committee. It bears the earmarks of thoroughness and is not a report that should be passed over lightly. Of course, it goes to the Committee on Standards. It is to be hoped the committee will be continued.

Mr. Blackmore: For one I would like to be relieved from that committee, as a report like that would involve a great deal of work. A large amount of the information as furnished in that report was literally drawn with forceps out of the people that I came in contact with. In addition to the printed report I had typewritten letters sent out to a lot of people in the trade that I knew that I felt I had some claim on. Yet even in such cases I found it difficult to get written replies. It doesn't seem that it is necessary to continue this committee at this time to continue its investigations, but in the course of a year or two hence the matter could be taken up again. I do not feel I can give it any more time than I have really given it.

President Mackay: I appreciate your position. You are a busy man and have a thousand and one things to look after. I believe every committee should be discharged in the regular way as they have performed their duty and as they have brought to a head that work for which they were appointed, and then if there is more work to be done along that line they should be continued later. All this committee work should go to the Committee on Standards and there put in shape for submission to the Board. The work done is very valuable.

Mr. Barwick: My idea would be to ask the committee to retain the matter until the summer meeting. I think it would be very well for them to continue this matter for another season at least. However, I feel that they have gone as far as they can go under the present arrangement, and I am perfectly willing to withdraw my motion.

Mr. Chew: I want to say one word. Mr. Blackmore got several answers to his letter. The committee I served on got but

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one answer. It is the hardest thing possible to get the people of this Society to talk about things they know about. I appreciate Mr. Blackmore's position, being a busy man, nevertheless I hope Mr. Blackmore will stay until the summer meeting at least. If the report is in the possession of the members in black and white they can easily give further information on it.

After some discussion the motion made by Mr. Chew was agreed to.

Mr. Barwick: Our Committee on Air Washers asks to be continued for this reason: Our committee was appointed rather late in the season and it was rather hard for us to gather any particular data. We have endeavored in some way to formulate a schedule by which we could make some tests of air washers. Mr. Harrison, Mr. Lewis and Mr. Davis have given quite some consideration to the matter. I have been invited by two or three parties to look over their plants, and I expect soon to be able to give the necessary time to it. Mr. Harrison will look over a plant at Camden and will also look over some other apparatus that has been installed in New York.

Mr. Donnelly, J. A.: I believe two years ago the Committee on Standard Sizes of Steam and Return Mains made a report. I think the committee made some recommendation regarding putting it on the programme. I would like to see the subject discussed and the committee discharged.

President Mackay: As I understand it, the report is in the hands of the Committee on Standards, and the report of the committee is in the volume just about to be issued.

Mr. Donnelly: The report was laid upon the table at the evening meeting two years ago, and the report is still on the table if you wish to take it up.

President Mackay: I agree that something in the way of tangible action should be taken, but it is, perhaps, difficult under some conditions to get final report from the Committee on Standards. That is a work that might be brought to a head. Your committee's work was satisfactory and brought out a great deal of information.

Mr. Donnelly: I move the report be taken from the table, read and discussed.

(The Chair read from the Proceedings the action taken on the report in question.)

President Mackay: Is there any discussion on the report I just read of the committee to collect data on steam mains? (None.)

Mr. Hale presented the following report from the Illinois Chapter.

REPORT OF THE ILLINOIS CHAPTER.

Mr. President: The Illinois Chapter of this Society wishes to report that it is still holding its regular monthly meetings from October to May, inclusive, and each meeting has been so well attended that we are assured of a continuance of our prosperity and interest in the Society's affairs. The membership has increased slightly, we having admitted two new members and lost one by death during the year. This gives us a present membership in the Chapter of 30, out of a total of 53 in the State.

At our monthly meetings we usually have from fourteen to seventeen present, although our full membership is interested and all are working members. There has never been a time when all the members have been in the city, and this accounts for the small attendance as compared with the membership.

We have found that we have a better attendance when a meeting is held in connection with a dinner, although each member is called upon to pay his share of the expense, and for this reason we have had but one meeting this year in the rooms of the Western Society of Engineers.

Our annual election took place on Monday, October 11, 1908, the following being the result of the ballot:

GEORGE MEHRING, President,
E. F. CAPRON, Vice-President,
JOHN F. HALE, Secretary,
AUGUST KEHM, Treasurer.

BOARD OF GOVERNORS.

JAMES MACKAY,
SAML. R. LEWIS,
ROBERT A. WIDDICOMBE.

At our November meeting we listened to a very interesting talk by Mr. Mehring, describing the heating and ventilating ap-

paratus in the gymnasium at the University of Chicago, and this was followed by a general discussion of methods employed to ventilate buildings of this type and particularly the locker rooms. This talk was illustrated with the working drawings and brought out the usual difficulties met in connection with apparatus of this kind and showed how they were overcome.

At our December meeting Mr. Hale exhibited drawings from which the ventilating apparatus was erected in the new Majestic Theatre Building, at Milwaukee, in which the entire space beneath the parquet was used as a plenum chamber from which heated air was admitted into the auditorium through 6-inch tubes, set into the concrete floor beneath the seats. A discussion followed and the various members expressed themselves for or against the methods employed. The fact that the system was a success proved, however, that one does not have to follow any hard and fast lines to get results, but must modify his layout to suit local conditions.

The one prominent fact brought out was the lack of space provided by architects for the proper installation of apparatus, and it was shown that the contractors frequently find it impossible to install a system in accordance with ventilating laws owing to the lack of space provided for the admission of ducts.

Mr. Capron exhibited a set of plans showing a hot water apparatus which he was called upon to change over owing to the lack of circulation in certain parts. He first showed the plant as it was, and asked for suggestions as to the best method of overcoming the difficulties, and afterward told what changes he had made in order to get results. This was a most interesting discussion, as it brought out many different theories and ideas on the subject.

Our January meeting was held on the 11th inst., at which time we listened to a report from our local committee on tests, which report will be forwarded to the National Committee. This report related exclusively to the testing of cast-iron radiation of various heights and widths, and brought out some interesting facts regarding the efficiency of radiation when bronzed as compared with enamel as a finish, this being much in favor of the latter in every case. The effect of placing a seat above a low radiator was dwelt upon, showing a rapidly decreasing efficiency as the seat was brought closer to the top of the radia-

tor, the nearest point permissible without ill effects being 3 inches.

Mr. Samuel R. Lewis described the heating and ventilating apparatus installed after his design in a large school building where he used a fan with tempering coils near the centre of the building, distributing tempered air to groups of indirects so located as to give an equal distribution to all points of the building. A very important feature called to our attention was the possibility of opening the by-pass around the reducing valve and a corresponding valve in the return, thus admitting steam direct to the system and allowing a gravity circulation to prevail even after the fan had stopped and the steam had dropped to a very low pressure. The especial advantage of this method over the combination system using direct and blast was the possibility of maintaining temperatures over night without giving the system any particular attention.

Our local committee on compulsory legislation for the ventilation of public buildings is preparing to present the bill to the present legislature. This bill was printed and ready for the first reading at the last legislature two years ago, but was not reached during the session. We are assured by our committee that they have matters well in hand, and there is no question but that the bill will go before the house and we are hopeful of having it passed. This bill is similar to the ones passed in the States of Massachusetts, New York and Pennsylvania.

We have in view some very good papers for the remaining meetings of this year, and from our experience we would recommend that other State chapters be organized, in which case we will be glad to give them the benefit of our experience in organization and carrying out the work.

Respectfully submitted,

JOHN F. HALE,
Secretary.

President Mackay: We will pass to the appointment of tellers. I appoint as tellers John R. Shanklin, James B. Badger, and F. G. McCann.

Your duties are to count the votes and the report will be the first number on the evening session.

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Mr. Barwick: Under the head of "new business" I would like to say something in reference to one of our members, Mr. Enoch Rutzler. It devolves upon the Society to pass some resolution by which we may recognize the death of one of our oldest steam fitters of New York. I feel it is the duty we owe to his widow.

President Mackay: I think some notice is taken of it in our last volume. He died the early part of this year.

Mr. Chew (exhibiting last volume): I believe this is new practice in our Proceedings, one page set apart, with a black border, within which is recorded the names of the different members, the time they became members, time of their death, so in the Proceedings of next year Mr. Rutzler's name will be added to the list "in memoriam."

Mr. Barwick: This meeting should take some action in the matter.

Mr. Donnelly: I move the Secretary be instructed to write a letter to the family of Mr. Rutzler, and express the sympathy of our Society at his loss.

Which was duly seconded.

Mr. Donnelly: I wish my motion to include also the death of the representative of the Illinois Chapter, H. J. Ott.

The motion was agreed to.

Mr. Chew (addressing President Mackay): In your address you mentioned the death of Alfred R. Wolff. I know from talking with Professor Carpenter and others that, notwithstanding Mr. Wolff was not a member of this Society, he had a deep interest in its welfare. We had the man's thorough sympathy, and anything that was in his possession and needed by any of our members could be had. Considering the exceptionally high plane he occupied in his field, I think the Society should go on record, and I make a motion that a letter be sent to his family of the same nature as sent to the others.

Which was seconded and agreed to.

Mr. Donnelly: I would like to suggest it would be well to collect such data as we can upon the subject of fire protection and fire risk. The Secretary says we haven't any data on the subject and do not publish anything.

Secretary Mackay: Mr. Donnelly asks for information on the fire protection. Soon after we became members I wrote

the Fire Protection Association and received this reply last August:

NATIONAL FIRE PROTECTION ASSOCIATION.

382 Ohio Street, Chicago, August 20, 1908.

The American Society of Heating and Ventilating Engineers, P. O. Box 1818, New York, N. Y.:

Gentlemen: Your valued favor of August 1st did not reach the office until after I left for the East to attend the meeting of the Executive Committee, in which special committees for the ensuing year were appointed. I regret that I did not have your suggestion for new committee on "Necessary Fire Protection in Connection with the Installation and Operation of Heating and Ventilating Apparatus" in time to bring it before the meeting.

As to a representative of your Society on Committee on Uniform Requirements, this can easily be arranged by correspondence, and if you will be good enough to nominate a representative I will place the matter promptly before our officers and committee and have the necessary formality completed. I am also communicating with our President and Chairman of the Executive Committee in reference to your suggestion as to a new committee, and will advise you further on hearing from them.

Faithfully yours,

W. H. Merrill,
Secretary.

President Mackay: That answers your question, Mr. Donnelly? Arrangements are already being perfected for our organization being recognized upon their committees.

Mr. Donnelly: One other point. The Fire Protection Association have their meetings in the spring. I have attended some in New York and in Philadelphia which have been quite interesting. I do not think any member of this organization received any printed matter from them unless he joined. I received a copy last night.

President Mackay: I appoint as a committee to audit the accounts of the Treasurer, Messrs. Seward, Lewis and Davis.

On motion the session adjourned.

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First Day—Evening Session.

(Tuesday, January 19, 1909.)

The meeting was called to order at 8.20 P.M. by President Mackay.

President Mackay: The first order of business is the report of tellers.

The report was read as follows:

New York, January 19, 1909.

Your tellers beg to report the result of the ballot for officers, as follows:

Total vote cast, 148.

President.

Wm. G. Snow	99
Jas. D. Hoffman	48
Blank	1

First Vice-President.

August Kehm	100
Charles R. Bishop	48

Second Vice-President.

Burt S. Harrison	94
Edmund F. Capron	54

Secretary.

Wm. M. Mackay	138
Herbert A. Joslin	10

Treasurer.

U. G. Scollay	112
L. B. Sherman	30
Blank	6

Board of Governors.

R. C. Carpenter	133
Jas. Mackay	129
Jno. R. Allen	87
B. F. Stangland	85
Samuel R. Lewis	73
P. H. Seward	58
B. H. Carpenter	53
J. F. Hale	53
Jno. S. Brennan	39
Cesar Teran	22

J. R. SHANKLIN,
J. B. BADGER,
F. G. MCCANN,
Tellers.

Mr. Chew: I want to make a suggestion. This afternoon in the President's report he called attention to the value of the information that is in our volumes of Proceedings for several years back, and the advantages it would be to the Society to have a review meeting, with the idea of bringing some of the information up to date and bringing before a larger portion of the membership what the Proceedings contain. Within the past five years the membership of the Society has greatly changed. Many have gone out, and so many new members have come in that to a certain extent the new members are not thoroughly informed as to the objects of the Society and the plan of its work. Holding a meeting of the Society for a review of what has been done it seems to me would be invaluable. And for that reason I make a motion that the next meeting of this Society be devoted to a review of the work done, and a committee of five, consisting of the retiring President, the incoming President, and three others, be appointed to report before this meeting adjourns some plan for conducting such a review meeting as I suggest.

The motion was seconded and agreed to.

Mr. Weinshank presented the following report:

REPORT OF THE COMMITTEE ON TESTS.

Your Committee on Tests begs permission to submit the following report:

It has been the endeavor of your committee the past year to serve the Society in every way possible by collecting and compiling such test data as were available. In pursuance of this the following letter was addressed to each member of the Society:

To the Members of the American Society of Heating and Ventilating Engineers:

Your Committee on Tests begs to urge upon the members the value of bringing before the Society all the test data that have not hitherto been up for discussion.

Most of the members during the year come in contact with some material that would be very appropriately compiled by this committee if it were only known.

May we urge in behalf of the Society that each member forward to the Chairman, or to any member of the committee, any data thus obtained, and they will be made a part of the Society records.

Respectfully,

J. D. HOFFMAN, Chairman.
R. A. WIDDICOMBE,
THEO. WEINSHANK,
W. L. BRONAUGH,
EUGENE P. BRADLEY.

Three sets of data were received from the membership in response to this letter. These data are herewith submitted, and it is the sense of your committee that they should be printed in the Transactions, in the full belief that more material of like nature will be forthcoming in the near future. This will be of value not only to your "Committee on Standards," but to the whole membership of the Society.

DATA OF TEST ON TWO CAST IRON HOUSE HEATING STEAM BOILERS. TEST MADE NOVEMBER 24, 1908.

Submitted by Mr. Roy E. Lynd, Junior Member, Dover, N. J.

The tests, data of which follow, were made upon two boilers connected in the same manner to the same flue. The opening in the ash pit below the grate for air inlet was proportionally the same for each boiler. The fire was built with wood and coal, which had both been weighed. The fire was allowed to burn until the boiler ceased to steam. The total time from lighting the fire

to the time when the boiler ceased to steam was the number of hours used to get the average rate of fuel consumption, average rate of evaporation, etc. Boiler No. 1 showed a higher rate of combustion and a higher absorption of heat per square foot of heating surface than boiler No. 2, and at the same time showed less efficiency. The B. T. U. per pound of coal utilized in the boiler is almost exactly proportional to the ratios of heating surface to the grate surface. Compare items (4) and (36) in the two tests. Item (20) is figured from actual rate of evaporation in the middle of the test after everything had been warmed up and the fire had a bed of bright coals to the full depth of the fire box, and upon a uniform average rate of combustion throughout the test. This last assumption is possibly not strictly true, as the fire should burn much faster in the middle of the test, when the coals were clear and bright and no part of their surface or of the voids between them had been deadened by ash. The calorimetric equivalent of the boiler, and also the radiation from the surface of the boiler were allowed for, as the test was started with the boiler cold, and the boiler was not covered. An average of items (16) and (20) would indicate that the customary allowance of 8,000 B. T. U. per pound of coal is conservative for both of these boilers, although boiler No. 1 is conservatively rated and boiler No. 2 is overrated.

DATA OF TEST OF TWO CAST IRON HOUSE HEATING STEAM BOILERS.
TEST MADE NOVEMBER 24, 1908.

		Boiler No. 1		Boiler No. 2
(1)	Description of Boiler	Cast Iron Sectional		Steam Boilers
(2)	Square feet grate surface	9.225		15.42
(3)	Square feet heating surface	116.		222.2
(4)	Ratio heating surface to grate surface	12.6 to 1		14.4 to 1
(5)	Square feet exposed surface	80.		104.4
(6)	Pounds wood used (total)	90.		157.
(7)	Calorific value of wood, B. T. U. per lb	5000.		5000.
(8)	Total pounds of coal used	400.		632.
(9)	Calorific value of coal, B. T. U. per lb	14000.		14000.
(10)	Equivalent total pounds of coal	432.		688.
(11)	Equivalent pounds coal per sq. ft. grate	46.8		44.7
(12)	Equivalent pounds coal per sq. ft. grate per hour	7.2		5.1
(13)	Pounds water fed to fill boiler	693.		1424.
(14)	Pounds water evaporated	2166.		3733.
(15)	Equivalent evaporation per hour from and at 212 degrees. Pounds	437.8		584.6
(16)	Equivalent evaporation from and at 212 degrees per pound coal	6.59		7.44
(17)	Equivalent evaporation from and at 212 degrees per sq. ft. grate per hour	47.45		37.94
(18)	Maximum actual rate of evaporation per hour reached during test	600.		706.
(19)	Maximum equivalent evaporation per hour from and at 212 degrees, from (18)	21.2		847.8
(20)	Maximum equivalent evaporation from and at 212 degrees per pound coal	10.85		10.64
(21)	Maximum equivalent evaporation per hour from and at 212 degrees per sq. ft. grate	78.12		54.26
(22)	Average temperature feed water	53.		50.8
(23)	Average temperature steam at 0 lbs. pressure	212.		212.
(24)	Average temperature boiler ..... For 0.5 Hr.	132.	0.75 Hr.	131.4
	For 6. "	200.	8. "	200.

	Boiler No. 1 Cast Iron Sectional	Boiler No. 2 Steam Boilers
(25) Average temperature room	65.	55.5
(26) Average temperature flue gases	Not taken	...
(27) Time in hours from starting fire to reaching pressure of 0 lbs.	0.5	0.75
(28) Time in hours from reaching pressure of 0 lbs. to end of test	6.0	8.0
(29) B. T. U. supplied to heat original water to temp. (23)	110810.	230550.
(30) B. T. U. supplied to evaporate (14) lbs. water at temperature (23)	2438100.	4351200.
(31) B. T. U. radiated from boiler during test	109890.	189800.
(32) B. T. U. absorbed by boiler in heating from (22) to (24)	89053.	168550.
(33) Total B. T. U. supplied by (10) lbs. coal in (27) plus (28) hours	2747853.	4940100.
(34) B. T. U. per sq. ft. grate per hour	45826.	36614.
(35) B. T. U. per sq. ft. heating surface per hour	3644.	2541.
(36) B. T. U. per pound coal	6365.	7180.
(37) Efficiency of boiler	45¼%	51.3
(38) Steam rating* from (15)	1691.	2258.3
(39) Steam rating from (19)	2786.	3275.
(40) Advertised steam rating	2250.	4400.

* Square feet of direct steam radiating surface to be supplied by boiler, on basis of 1 sq. ft. = 250 B. T. U. per hour.

FORMULÆ FOR CALCULATIONS.

(10) Equivalent total pounds of coal: $(6)\frac{5000}{14000} + (8)$

(11) Equivalent pounds coal per sq. ft. grate: $\frac{(10)}{(2)}$

(12) Equivalent pounds coal per sq. ft. grate per hour: $\frac{(11)}{(27) + (28)}$

(15) Equivalent evap. per hour from and at 212 degrees. Pounds: $\frac{(33)}{965.7\,[(27) + (28)]}$

(16) Equivalent evap. from and at 212 degrees per lb of coal: $\frac{(33)}{965.7(10)}$

(17) Equivalent evap. per hour from and at 212 degrees per sq. ft. grate: $\frac{(33)(12)}{965.7(10)}$

(19) Maximum equivalent evap. per hour from and at 212 degrees from (18): $\frac{(18)[H_{212} - h_{(22)}] + 1.5(5)[(24) - (25)}{965.7}$

(20) Maximum equivalent evap. per hour from and at 212 degrees per lb coal: $\frac{(19)[(27) + (28)]}{(10)}$

(21) Maximum equivalent evap. per hour from and at 212 degrees per sq. ft. grate: $\frac{(18)[H_{212} - h_{(22)}][(27) + (28)](12)}{965.7(10)}$

(24) Average temperature boiler: (See note below)

(29) B. T. U. supplied to heat original water to temperature (23): $(13)(h_{212} - h_{(22)})$

(30) B. T. U. supplied to evaporate (14) lbs. water at temperature (23): $(14)(H_{212} - h_{(23)})$

(31) B. T. U. radiated from boiler during test: $(5) - 1.5\left[(27)\left(\frac{212 + (22)}{2} - (25)\right) + (28)\left(200 - (25)\right)\right]$

(32) B. T. U. absorbed by boiler in heating from (22) to (24): = (weight of boiler) × .13 × [200 — (22)]

(33) Total B. T. U. supplied by (10) lbs. coal in (27) plus (28) hours: = (29) + (30) + (31) + (32)

(34) B. T. U. per sq. ft. grate per hour: $\frac{(33)}{(2)[(27) + (28)]}$

(35) B. T. U. per sq. ft. heating surface per hour: $\frac{(33)}{(3)[(27) + (28)]}$

(36) B. T. U. per pound coal: $\frac{(33)}{(10)}$

(37) Efficiency of boiler: $\frac{(36)}{14000}$

(38) Steam rating from (15): $\frac{(15) \times 965.7}{250}$

(39) Steam rating from (19): $\frac{(19) \times 965.7}{250}$

Note 24 $= \frac{212 + (22)}{2}$ for (27) hours

and $\frac{(h_{212} - h_{(22)})(t_f - 212)\left(\frac{(212 + (22)}{2}\right) + 965.7\left(t_f - \frac{212 + (22)}{2}\right)212}{(h_{212} - h_{(22)})(t_f - 212) + 965.7\left(t_f - \frac{212 + (22)}{2}\right)}$.

For (28) hours in which t_f equals average temperature of fire and flue gases.

SUMMARY OF TEST DATA TAKEN FROM TWO TESTS UPON A CENTRALIZED HOT WATER HEATING AND ELECTRICAL GENERATING PLANT.

Data submitted by J. D. Hoffman, La Fayette, Ind.

The first test was run in 1906 and the other in 1908. The results obtained check very well with a similar test made in 1904, the data from which are not included here. The plant underwent a number of minor changes between the tests; but the main features remained unchanged. The values given are averaged for the entire test in each case, and the B. T. U. values were approximated to the thousand. Only a partial summary is given. For heating the water a 1,000-foot surface condenser, especially built for the exhaust steam of the plant, was used in connection with water-tube heating boilers. The principal pieces of apparatus in the plant connected to the steam supply during the last test were as follows:

2—125-H. P. water-tube boilers.
3—250-H. P. water-tube boilers.
1—450-H. P. horizontal low-speed Corliss compound engine.
1—125-H. P. vertical high-speed compound engine.
1—250-H. P. vertical high-speed compound engine.
1—centrifrugal, two-stage circulating pump.
2—horizontal duplex, reciprocating pumps, 14″x 12″ x 18″.
4—small horizontal, reciprocating pumps.
1—1,000-square foot heater.

TABLE I.—PARTIAL SUMMARY OF RESULTS.

	1906	*1908*
1. Square feet of radiation	118,000	150,000
2. Temperature of circulating water in degrees F., flow main	158.36	164.4
3. Temperature of circulating water in degrees F., return main	139.9	139.6
4. Temperature of circulating water in degrees F., after leaving heater	145.6	147.
5. Temperature of outside air in degrees F	32.6	37.5
6. Temperature of stack gases in degrees F., steam boiler	.....	566.8
7. Temperature of stack gases in degrees F., heating boiler	562.	656.
8. Draft in stacks (all boilers averaged) in inches of water	0.689	0.595
9. Heating value of coal in B. T. U. per pound	12800.	11565.
10. B. T. U. delivered to steaming boiler per hour by coal	18,187,000	25,833,000
11. B. T. U. delivered to heating boilers per hour by coal	19,226,000	27,917,000
12. B. T. U. delivered to circulating water by heating boilers per hour	11,800,000	15,405,000
13. B. T. U. to be charged to heating boilers (Item 12—Item 15)	7,650,000	6,934,000
14. B. T. U. delivered to circulating water by exhaust steam from the generating engines per hour	3,600,000	6,602
15. B. T. U. thrown away during test from pump exhausts and available for heating circulating water	4,150,000	8,471,000
16. B. T. U. available for heating circulating water from all exhaust steam as in normal running (Item 14 + Item 15)	7,750,000	15,073,000
17. Total B. T. U. given to circulating water per hour (Item 13 + Item 16)	15,400,000	22,007,000
18. Gallons of water pumped per hour [Item 17 ÷ (8.33 — Items 2 — 3)]	100,000	108,000
19. Gallons of water pumped per sq. ft. of radiation per hour (Item 18 ÷ Item 1)	0.85	0.70
20. Efficiency of heating boilers (Item 12 ÷ Item 11) approx	0.60	0.55
21. Value of coal in cents per ton of 2,000 pounds at the plant	200.	175.
22. Average electrical horse power	68.	141

The deductions, Table II, are made from the following formulæ and Table I, for the cost of heating radiation for the average year when considered under three conditions, *i.e.*, A, B, C.

(A) Assuming all heating to be done by heating boilers.

(B) Assuming the heat from the exhaust steam from the electrical plant and the smaller pumps to be a credit to the heating system.

(C) Assuming all the exhaust steam to be a credit to the heating system.

The average temperature of the seven cold months was taken from statistics covering 20 years' time, to be 38 degrees F. All results of the test, therefore, are reduced to this figure.

FORMULÆ.

$$(A) = \frac{\text{Item } 17 \times 5040 \times \text{Item } 5 \times \text{Item } 21}{\text{Item } 9 \times \text{Item } 20 \times 2000 \times 38.}$$

(B) = Substitute in A, (Item 17 — Item 14) for Item 17.

(C) = Substitute in A, (Item 17 — Item 16) for Item 17.

TABLE II.

	Cost of Total Radiation for Average Year in Dollars.	Cost of One Square Foot for Average Year in Cents.
Test of 1906, 118,000 sq. ft. A	8,670.00	7.35
Test of 1906, 118,000 sq. ft. B	6,676.00	5.60
Test of 1906, 118,000 sq. ft. C	4,306.00	3.65
Test of 1908, 150,000 sq. ft. A	15,057.00	10.00
Test of 1908, 150,000 sq. ft. B	10,540.00	7.00
Test of 1908, 150,000 sq. ft. C	4,700.00	3.12

The following letter was sent to nineteen companies manufacturing radiation.

"Gentlemen: The following questions are submitted to you in behalf of the American Society of Heating and Ventilating Engineers by the Committee on Tests. It is the desire of the committee to gather together and formulate into a brief concisive statement such data as can be obtained on the measuring, testing, and rating of cast iron direct and indirect heating surface. The following questions are, therefore, proposed to you in the hope that you will give us a short, concisive statement upon all points wherein you have had experience or information.

"1. What is your method of determining square feet of radiation in any cast iron radiator section?

"2. Have you conducted any efficiency tests on radiators? What is your method of conducting such tests? Give the outline. This should include a diagram of piping connections and method of catching and measuring condensation. Make as definite as possible.

"3. Have you any test data on direct radiation not published previously? If so, you will submit such data to the Society? If you have any test data that have been published, will you please state where the same may be found, or send copy?

"4. Have you a summary giving pounds of water condensed per square foot of radiator surface per hour under various conditions of use? If so, will you submit the same?

"5. Have you made any tests on indirect heating surface to determine the pounds of water condensed per square foot of radiator surface per hour under various conditions of use? If so, will you submit a summary?

"6. Have you made any test on direct-indirect heating surface to determine the number of pounds of water evaporated per square foot of radiator surface per hour under various conditions? If so, will you submit a summary?

"The committee understands of course that to answer such questions as fully as they should be answered requires time, and men in business are usually pressed for time. However, since we are all working for the building up of the Society records, and for the standardizing of the various makes of radiators, it appeals to the committee that time so spent is well spent. May we hear from you in regard to this.

"Awaiting your reply, we beg to remain, respectfully,

"Signed by the Committee."

Replies were received from eleven of the nineteen companies. A summary is as follows:

Two companies reported that they had made no tests and had no data on the subject.

Two companies reported that they had made no tests, but that they would be willing to do so if the committee did not obtain the desired information otherwise. One of the two companies wished the coöperation of a representative of the committee in the making of such tests. Both companies were willing to furnish radiation for the committee's use.

One company reported that certain radiator tests were then in progress, and that they would be glad to report results later. This report has not yet come to hand.

Four companies reported that they had tests made by reputable engineers, and that the company had no data at hand.

One company referred the matter to their consulting engineer with a promise that the committee would hear from them later. So far no reply has been received.

Two companies answered the questions in detail, but these replies were of such a character as to give the committee little actual information.

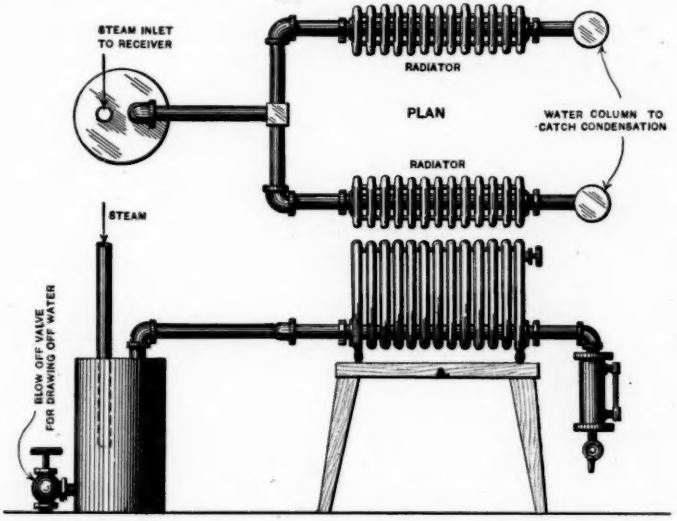
A partial summary is here given.

Concerning question 1, *i.e.*, measurement of radiating surface, one company replied as follows:

"Our method of determining the measurement of a radiator is by considering the column of a radiator as a tube; and as all measurements are made on the 38-in. radiator as a basis, we have considered this radiator (without the legs) as 3 ft. high—so that a two-column radiator would have

two tubes, measuring in circumference not less than 16 in., or each tube having 8 in., and such tube being 3 ft. long would contain 2 sq. ft. of surface. The question as to whether the top and bottom closing portions of each tube if opened out would be equivalent to the tube itself, might be open to some discussion, but we have always considered it near enough for all practical purposes."

Concerning questions 2 and 3, *i.e.*, the testing of the radiators, those companies making tests were interested in the comparative value of one radiator with another, *i.e.*, relative efficiencies. Tests made by the engineers not interested in the companies were from the standpoint of actual efficiencies. In such cases the tests had been made a number of years ago, and the data had been lost. One company submitted the following plan and elevation of pipe connection for such tests:



"Instructions for operating:

"After both radiators are heated up thoroughly and all water is drained out of water columns, then close both valves at bottom of columns and allow the water to gather in column until it reaches nearly to top of glass. Both columns are then drained to bottom of glass, but never breaking the water seal. The water drawn off is weighed. This process is continued for any length of time desired to get a fair average."

Concerning question 4 no information could be obtained excepting one reply which was upon wall radiation. This reply is as follows:

"I enclose you herewith the results of a series of tests made at Cornell University, showing the actual efficiency of our several forms of wall radiation."

Four Sections arranged horizontally.	*Rated surface, 28 square feet.*			
Number of test	1	2	3	4
Average steam pressure above atmosphere	10	7	5	2
Barometer reduced to pounds	14.4	14.4	14.4	14.4
Absolute steam pressure, pounds	24.4	21.4	19.4	16.4
Average temperature of surrounding air, Deg. F.	81	76	79	78
Temperature of steam	240	232	228	220
Quality of steam per cent	100	super heat	super heat	super heat
Duration of test, hours	1.91	2	2	2
Total weight of steam condensed, pounds	20.875	22.16	20.656	19.81
Difference of temperature, steam, and surrounding air, degrees	159	155.6	147	140
Total heat per pound of steam.....B. T.U.	1155.4	1152.6	1152	1148.3
Total heat per pound condensing water. "	207.5	200.4	195.1	186.2
Heat radiated per pound..... "	947.9	952.2	956.9	962.1
Total heat radiated..... "	19787.6	21098	19764.9	19059.8
Heat radiated per hour per degree difference of temperature, steam and air.....B. T. U.	65.6	67.88	67.2	68.07
Ditto as above per sq. ft. actual surface. "	2.18	2.261	2.24	2.270
Ditto as above per sq. ft. rated surface. "	2.34	2.43	2.40	2.43
Weight of steam condensed per hour.....lbs.	10.92	11.08	10.33	9.90
Ditto per sq. ft. actual surface	0.364	0.369	0.344	0.330
Ditto per sq. ft. rated surface	0.390	0.394	0.368	0.354

Actual surface as measured 7.5 per section, or 30 sq. ft. per radiator.

Concerning questions 5 and 6 no information was obtained.

In the replies from the various companies it was plainly seen that there was no uniformity in the methods of measuring the radiator surface, or in the methods of testing the same by the various manufacturers. The spirit of coöperation with the committee's efforts seemed to be fairly general, and in only one case was it apparent that the company was fully satisfied with its present methods. The customary way of obtaining the value of the product seems to be to refer that product in comparison to some other type that has already been successful and acceptable to the trade, regardless of its real value. Materials of the nature of radiators are what are considered a low-priced product, and the profit on the same is very small. Hence, the responsibility resting upon the manufacturer to make decisive tests to determine definitely what they will actually do, does not seem to warrant the manufacturers in making such tests.

A duplicate letter was also sent from the committee to the various companies manufacturing blower apparatus. This letter contained essentially the following:

"Gentlemen: We are addressing you to ascertain if you can provide the Society with any test data relating to the condensation in heater coils under the various operating conditions. The information we desire is positive information obtained from actual tests, and in case you have any such information which you will give to the Society for the benefit of the profession at large, we should like to receive the same in as complete a manner as possible with full description of the conditions under which test was made, and the manner in which the log was kept. We should like as full and complete information as possible along the following lines:

"1. What amount of condensation can be expected in the first section of

any group of coils with air at a given temperature and velocity passing over the coils?

"2. What effect does the spacing of the pipes have upon the condensation in a section?

"3. What effect does the varying of the air velocity have on the condensation?

"4. What rise in air temperature is secured at the various sections?

"We should like this information for one coil, two, three, four, five, six, etc.

"5. What resistance does the first section offer to the fan suction? Likewise the same information for a number of sections in a bank.

"Any information which you will furnish us is to be embodied in the report of the Committee on Tests to the Society at the January meeting, so we would greatly appreciate any assistance which you can give us."

No definite replies were received from these letters, but the committee has been informed that such material would be given if each company could be assured that the response from the various companies would be general.

In conclusion, the committee begs to suggest to the Society that the work is not as complete or as thorough as the committee would desire, and it is hoped that it may be carried on until the final report at a later date may cover the subject completely. It is also urged that the Society have expression at this meeting to the effect that any data sent in to the committee on tests will be considered strictly confidential and before being presented to the Society will have such names and classification stricken from them that they cannot be used for or against any one company.

Respectfully submitted,

J. D. HOFFMAN, Chairman.
R. A. WIDDICOMBE,
THEO. WEINSHANK,
W. L. BRONAUGH,
EUGENE P. BRADLEY.

Mr. Chew: I move that this report be ordered printed and distributed with Mr. Blackmore's report at the earliest convenience.

Mr. Weinshank: That is the sense of the committee. We think if this could be printed and distributed among the members and some of the figures verified, it would bring out not only a discussion, but information which some of you have and which we might use. If this is printed now possibly before the

summer meeting the committee could have more of a report to make.

The motion was seconded and agreed to.

President Mackay: We will pass to the next order of business, report of the committee to collect data on fan blast heating, Mr. Snow, Chairman.

Mr. Snow presented the report.

Mr. Snow: I would like to add in justification of this report that the committee used its best efforts to secure additional data from various members and manufacturers, and presented them in our first report last year, but we were not particularly successful in drawing out any additional information.

The report was discussed by Messrs. West, Snow, Macon and Weinshank.

REPORT OF THE COMMITTEE ON FAN-BLAST HEATING.

Your committee having been continued in service as voted at the annual meeting in New York, January, 1908, made an effort to secure additional data relating to the subject of hot-blast heaters.

It being the desire of your committee to secure as much information from as many sources as possible, certain non-members of our Society were communicated with. One of these, Mr. E. F. Child, replied that answers to nearly all our questions would be found in our article prepared by him, published in *The Metal Worker* of October 5, 1907.

A perusal of this article revealed much information to add to that already gathered, and with the permission of that paper your committee presents the substance of that article herewith. . . . . Table I gives the maker's ratings of volume to be discharged by the fan at the speed maintained during the tests; the velocity, as indicated from readings taken by means of a standard form of anemometer, and the volume as calculated from the amount of steam condensed taking into consideration the heat rise and other factors, as shown by the various columns of the table. The method used in obtaining this volume may be of interest, as it is simple and quite original.

For example, take test No. 7 from Table I as an illustration.

XUM

TABLE I.

Performance of Heaters in Connection with Fans.

Number of Test.	Makers' rating of fan, Cu. ft. per minute.	Air meter volume. Cu. ft. per minute.	Per cent. of makers' rating.	Volume calculated from steam condensed, &c.—Cu. ft. per minute.	Per cent. of makers' rating.	Ratio between areas of fan outlet and free area through heater.	Rows depth of heater.	Velocity over coils, based on calculated volume. Conde.	Steam pressure (gauge).	Entering air. Degrees F.	Leaving air. Degrees F.	Heat rise. Degrees F.	B.T.U. per lb. steam = latent heat + (temp. − 212°).	Total steam condensed per hour. Pounds.	B.T.U. per deg. diff. air and steam per sq. ft. per hour.
1	6,800	10,598	156	9,400	138	1:1.8	4	1,170	39	28	67	39	986	398	11
2	6,920	10,470	151	7,070	102	1:1.8	4	800	5	29	53	24	969	208	7
3	5,640	8,550	152	7,850	139	1:1.8	4	890	5	28	55	27	969	243	8.3
4	10,940	16,600	151	11,100	102	1:1.8	4	1,260	6	30	51	21	971	252	8.6
5	6,880	11,292	164	8,500	123	1:1.8	6	965	6	30	46	16	971	243	5.4
6	11,000	16,981	154	13,700	125	1:1.8	10	1,550	6	34	81	47	971	666	10
7	7,350	11,480	155	9,677	132	1:1.8	10	1,100	5	20	74	54	969	573	8.2
8	11,400	17,250	151	13,900	122	1:1.8	16	1,560	4	34	89	55	969	816	8
9	7,600	11,787	151	10,300	136	1:1.8	16	1,150	5	19	91	72	969	786	7.4
10	10,900	17,000	156	14,750	135	1:1.8	18	1,670	6	23	99	76	971	1,155	9.8
11	7,500	11,800	158	11,100	148	1:1.8	20	1,260	5	19	106	87	969	996	7.8
12	11,250	15,000	134	15,000	134	1:1.8	20	1,700	6	20	97	77	971	1,137	8.6
13	6,500	.....	...	8,350	129	1:1.12	28	1,550	5	36	153	117	969	930	12
14*	19,000	21,300	112	21,350	112	1:1.7	20	1,395	7	40	125	85	971	1,800	8.4
15	19,000	21,300	112	25,200	132	1:1.7	20	1,650	5	52	138	86	969	2,115	11.2
16	19,600	21,300	112	23,750	125	1:1.7	20	1,550	2	54	135	81	968	1,890	11
17	19,000	21,300	112	20,800	109	1:1.7	20	1,350	2	45	130	85	968	1,740	9.4
18	19,000	21,300	112	21,600	114	1:1.7	12	1,410	2	47	110	63	968	1,380	11.7
19	19,000	21,300	112	23,600	124	1:1.7	12	1,540	5	47	113	66	969	1,584	12.5
20	19,000	21,300	112	24,400	128	1:1.7	12	1,590	10	47	120	73	974	1,800	14.4

*Tests 14 to 20—meter volume taken only once—speed of fan constant for all.

The steam pressure is 5-lb. gauge, and the temperature of steam is taken as 227 degrees F. The latent heat is 954 B. T. U. per pound. This added to the sensible heat above 212 (227—212) gives 954 + 15 = 969 B. T. U. in each pound of steam available for heating purposes. In this test 573 lb. of steam was condensed per hour in a heater having 377 sq. ft. of surface, raising the air temperature from 20 to 74 degrees, or through 54-degree rise, in passing over 10 rows of 1-in. pipe.

The rated volume of air is 7,350 cu. ft. per minute, and the air meter indicated a volume of 11,480 cu. ft., which is 55 per cent. in excess of the fan rating. The 573 lb. of steam condensed in one hour at 969 B. T. U. per pound will give up 555,237 B. T. U., which equals 9,254 B. T. U. per minute. The specific heat of air is 0.2377. The heat [temperature] rise of air is 54 degrees. The volume of 1 lb. of air at 74 degrees is 13.45 cu. ft. Therefore, $9254 \div (54 \times 0.2377) \times 13.45 =$ 9,677 cu. ft., the volume of air passing over the heater per minute, which is 32 per cent. greater than maker's rating, but which is 16 per cent. less than the anemometer reading.

RADIATION PER DEGREE DIFFERENCE.

Since air enters at 20 degrees and leaves at 74 degrees, the average temperature is 47 degrees, and with steam at 227 degrees the average difference in temperature of air and steam is 180 degrees. From this the radiation per square foot of surface per degree difference between air and steam may be obtained as follows:

Total heat units, 555,237 B. T. U.; total heating surface, 377 sq. ft.; difference in temperature air and steam, average 180 degrees. Let E = radiation per square foot per degree difference air and steam,

Then $$E = \frac{555{,}237}{377 \times 180} = 8.18.$$

Volume of air is 9,677, free area through heater is 8.82 sq. ft., therefore the velocity of air passing over the coils is 1,100 ft. per minute, or 18.3 ft. per second.

At this velocity, using formula $E = \sqrt{4\ V}$, in which V = velocity of air in feet per second, the British thermal units per degree difference are 8.6.

Chart A shows a curve plotted from this last formula, upon

which has been indicated by means of crosses the results of the 20 tests shown in Table I, the velocity of air over the coils being figured from the volume obtained by calculations from the actual steam condensation, as described above. It will be observed that there is a wide variation in these results, but the curve strikes a

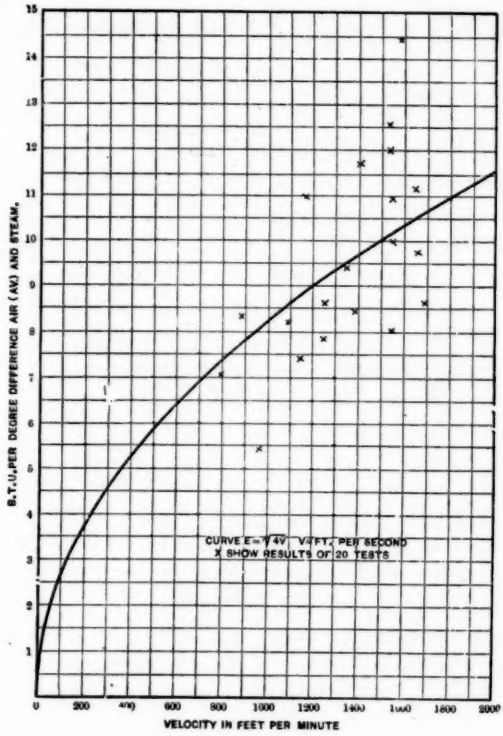


CHART A.

very fair average of them all, and it has been adopted as the basis for calculating the heat [temperature] rise of the air in passing over the coils.

RISE OF TEMPERATURE IN HEATER.

In calculating the rise in temperature it is not possible to consider the entire surface as a unit. The temperature of the air increases as it strikes each row of pipes and the condensation, and the corresponding heat rise are greater in the outside rows which

come in contact with the coldest air, and they gradually diminish as the air passes over the successive rows.

The figures for heat rise have been worked out row by row, taking a standard section containing 138 sq. ft. of surface in two rows, the free area between the pipes being 15.32 sq. ft. The calculations are made for 1,200 and 1,800 ft. per minute velocity of air passing over the coils and with the steam pressure 5 and 80 lb. gauge.

The air volume equals the area times the velocity. The weight is figured from the volume assuming a temperature of 130 degrees, which is the ordinary temperature of air discharged where buildings are heated by the fan system. From the above data the following formula has been derived:

$$R = \frac{(T_s - T_a) \times H \times E}{A \times V_m \times W \times 60 \times 0.2377.}$$

In which

R = Degrees Fahrenheit rise for each two-row section.

T_s = Temperature Fahrenheit of steam.

T_a = Temperature Fahrenheit of air.

H = Square feet of surface in two-row section.

E = British thermal unit per degree difference between air and steam.

$E = \sqrt{4\ V_s}$ in which V_s = air velocity in feet per second.

A = Area through heater in square feet.

V_m = Velocity of air in feet per minute.

W = Weight of 1 cu. ft. of air-pounds.

Then for rise in two-row section with 1,200 ft. velocity.

$$R = \frac{(T_s - T_a) \times 138 \times 9}{15.32 \times 1{,}200 \times 0.0676 \times 0.2377 \times 60.}$$

Solving: $R = (T_s - T_a) + 0.0704$.

Let $T_s - T_a = D$.

Then $R = D \times 0.0704$.

In like manner for 1,800 ft. per minute velocity we find that

$R = D \times 0.0573$.

From these two equations it is a simple matter to work out the rise in the successive two-row sections, and the result of these calculations is shown in Chart B. [A comparison will show that

the curves for 5-lb. gauge pressure are very close to the figures for heat rise given in Allen's "Notes on Heating and Ventilation," for 1,250 and 1,700 ft. per minute velocities, although that work does not state the steam pressure.] . . .

These curves have been carefully compared with a large num-

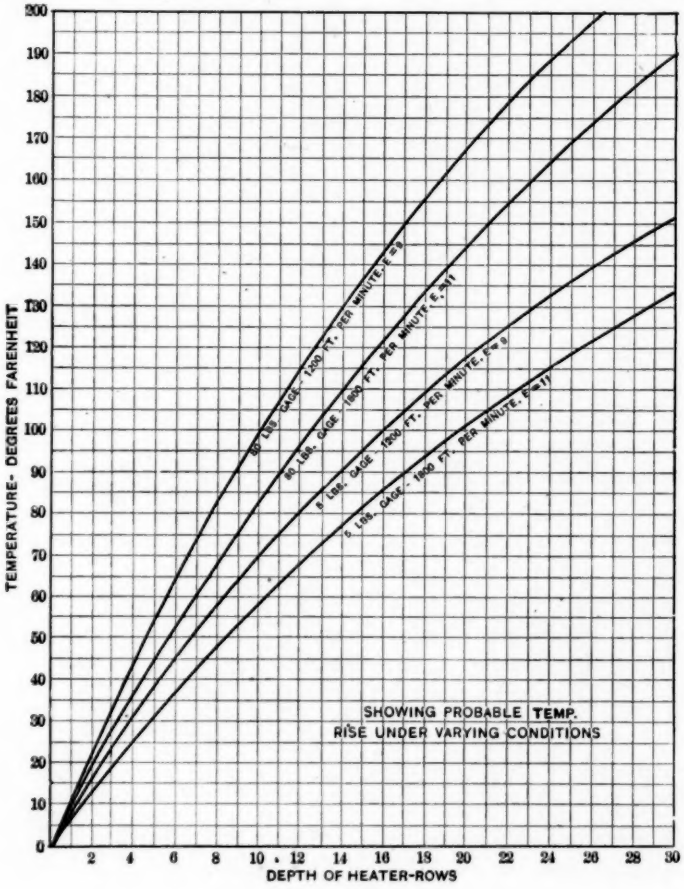

TEMPERATURE- DEGREES FAHRENHEIT
DEPTH OF HEATER-ROWS
SHOWING PROBABLE TEMP. RISE UNDER VARYING CONDITIONS
80 LBS. GAUGE - 1200 FT. PER MINUTE. E=8
80 LBS. GAUGE - 1800 FT. PER MINUTE. E=11
5 LBS. GAUGE - 1200 FT. PER MINUTE. E=8
5 LBS. GAUGE - 1800 FT. PER MINUTE. E=11

CHART B.

ber of heater tests, due allowance being made for corrections in volumes and velocities, and the results, while conservative, may be applied to all the standard types of pipe heater on the market, where the pipe spacing is relatively close.

DRAW THROUGH AND BLOW THROUGH HEATERS.

An important point which is generally overlooked by designers in calculations for sizes of fans and heaters is the question whether the fan draws or blows the air over the coils. The foregoing data are based on a heater of the draw through type, as that is more commonly in use. This type is to be recommended in a majority of cases on account of the even temperature of the air leaving the fan, due to the thorough mixing it gets in passing through the fan. With the blow through type the air passes directly into the ducts, and, if the circulation of the steam in the coils is not perfect, there is sometimes a tendency toward streaks of cool air in the heat ducts. It is sometimes desired to discharge air at different temperatures from the same apparatus, and in such an instance the blow through type with cold or tempered air by pass must be used.

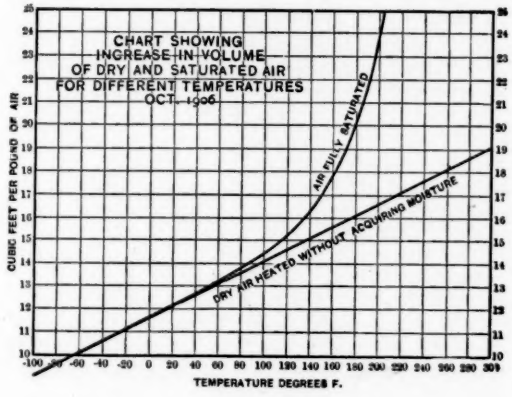


CHART C.

It is well known that the volume of air varies directly with its absolute temperature. This is shown by Chart C. On this chart has also been plotted a curve showing the volume of a pound of saturated mixture of air and vapor at different temperatures. The presence of vapor in air for heating may, however, be neglected, except where humidifying apparatus is used, as the quantity of water vapor at low temperatures is very slight, and the relative humidity of the heated air becomes less and less, as its temperature is increased, even though it may be saturated when it enters the heater.

A fan at a given number of revolutions per minute will, other conditions being equal, handle a constant VOLUME of air, irrespective of temperature.

Taking, for example, an extreme case, a fan drawing through a heater which raises the temperature from 0 degrees to 150 degrees F., and creating a velocity of 1,800 ft. per minute over the

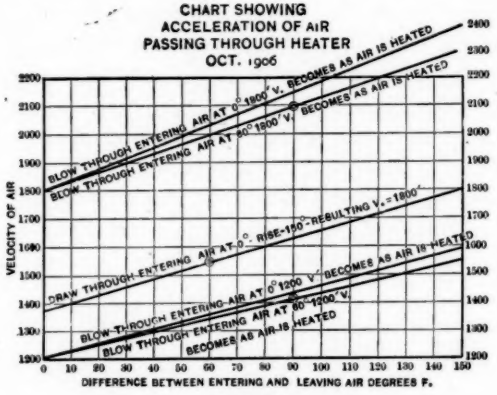


CHART SHOWING
ACCELERATION OF AIR
PASSING THROUGH HEATER
OCT. 1906
BLOW THROUGH ENTERING AIR AT 0° 1900' V. BECOMES AS AIR IS HEATED
BLOW THROUGH ENTERING AIR AT 80° 1900' V. BECOMES AS AIR IS HEATED
DRAW THROUGH ENTERING AIR AT 0° RISE-150°-RESULTING V.=1800'
BLOW THROUGH ENTERING AIR AT 0° 1200' V. BECOMES AS AIR IS HEATED
BLOW THROUGH ENTERING AIR AT 80° 1200' V. BECOMES AS AIR IS HEATED
VELOCITY OF AIR
DIFFERENCE BETWEEN ENTERING AND LEAVING AIR DEGREES F.

CHART D.

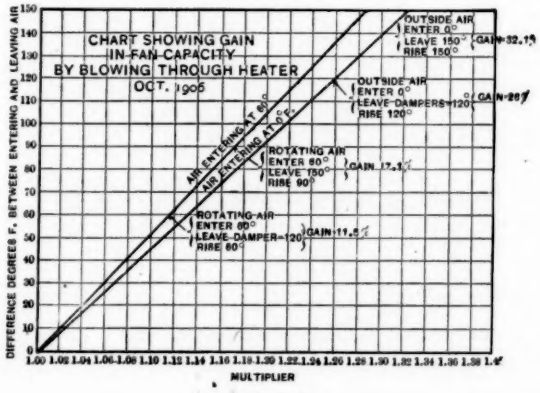


CHART E.

last row of coils will produce a velocity of less than 1,400 ft. per minute over the first row. If conditions are reversed, and the fan is made to blow through a heater, which under the new conditions is capable of raising the air from 0 degree to 150 degrees F., the free area through the heater being the same as before, the

velocity over the first row of coils will be 1,800 ft. per minute, and over the last row will be 2,400 ft. per minute. This has been worked out for varying conditions, and the results of the calculations have been plotted on Chart D.

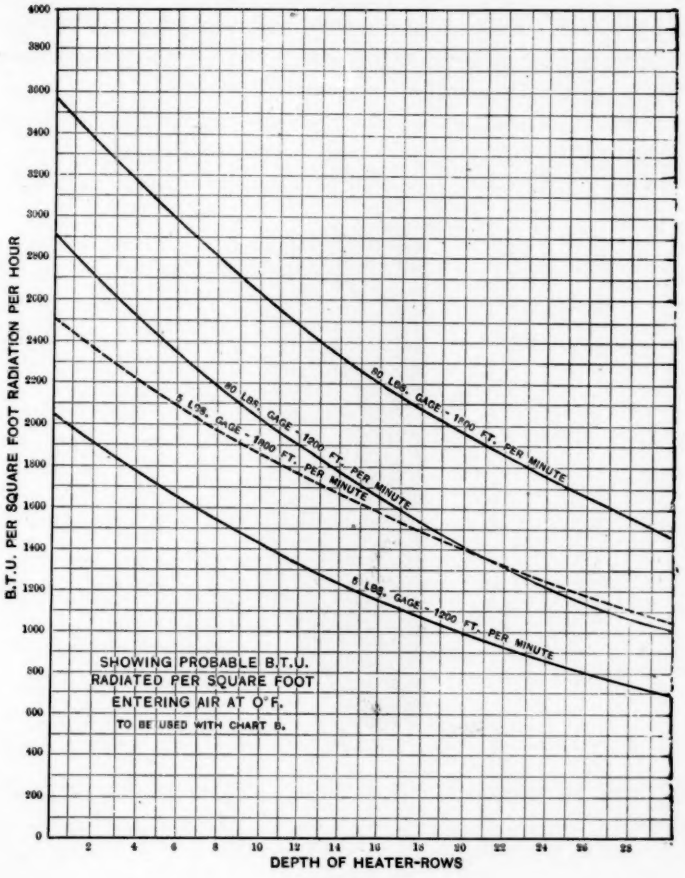


CHART F.

The percentage of gain has been replotted on Chart E, and a few notations have been made to show how the chart may be used.

CONDENSATION.

Using the curves for temperature rise as a basis (see Chart B), a computation has been made to determine the probable con-

densation per square foot per hour in each row of the heater, starting with air at zero, for varying conditions of air velocity and steam pressure. For ready reference the results have been plotted (see Chart F).

It is interesting to note that the condensation at 80-lb. gauge and 1,200-ft. velocity is not widely different from that at 5-lb. gauge pressure and 1,800-ft. velocity. This brings out very clearly the greatly increased capacity of coils at higher velocities. It is also interesting to note the rapid fall in condensation as the difference in temperature of air and steam diminishes.

Chart F must always be used in conjunction with Chart B, as

FIG. 1.

they are interdependent. For instance, if entering air is 30 degrees.

Steam is 5-lb. gauge.

Velocity is 1,200 ft. per minute.

Heater is 16 rows deep.

It will be noted that 30 degrees corresponds to four sections, so that for 16 more sections, or corresponding to 20 sections, the temperature of the air on leaving the heater is 117 degrees. The condensation, according to Chart F, should vary from 1,760 B. T. U. in the first row to 980 B. T. U. in the last row.

Tables and data relating to cast-iron hot-blast heaters presented by Mr. Theodore Weinshank at the 1908 summer meeting of this Society are repeated below, in order to put available data in one report which, when completed, is to be turned over to the Committee on Standards with the hope that a sufficient amount of information will be presented to enable that committee to recommend certain standards for this class of heating.

The type of heater referred to is illustrated in Fig. 1. The tables mentioned are as follows:

TABLE II.—RISE OF TEMPERATURE PER DEGREE DIFFERENCE BETWEEN TEMPERATURE OF STEAM AND MEAN TEMPERATURE OF AIR FOR DIFFERENT VELOCITIES OF AIR.—VOLUME OF AIR MEASURED AT 70 DEGREES.

Velocity, feet per minute.	Number of sections heater is deep.					
	1.	2.	3.	4.	5.	6.
1,600	0.124	0.253	0.395	0.527	0.649	0.761
1,500	0.132	0.261	0.403	0.535	0.657	0.769
1,400	0.139	0.268	0.410	0.542	0.664	0.776
1,300	0.147	0.276	0.418	0.550	0.672	0.784
1,200	0.154	0.283	0.425	0.557	0.679	0.791
1,100	0.162	0.291	0.433	0.565	0.687	0.799
1,000	0.170	0.299	0.441	0.573	0.695	0.807
900	0.177	0.306	0.448	0.580	0.702	0.814
800	0.185	0.314	0.456	0.588	0.710	0.822

TABLE III.—HEAT UNITS TRANSMITTED PER SQUARE FOOT OF HEATING SURFACE PER HOUR PER DEGREE DIFFERENCE BETWEEN THE TEMPERATURE OF THE STEAM AND THE MEAN TEMPERATURE OF THE AIR.

Velocity, feet per minute.	Number of sections heater is deep.					
	1.	2.	3.	4.	5.	6.
1,600	11.94	12.17	12.67	12.67	12.50	12.20
1,500	11.91	11.76	12.11	12.06	11.86	11.56
1,400	11.70	11.28	11.50	11.41	11.18	10.89
1,300	11.50	10.79	10.89	10.75	10.51	10.22
1,200	11.11	10.21	10.22	10.05	9.81	9.52
1,100	10.72	9.63	9.55	9.34	9.09	8.82
1,000	10.23	8.99	8.84	8.61	8.36	8.10
900	9.59	8.28	8.08	7.85	7.60	7.35
800	8.90	7.56	7.31	7.08	6.48	6.60

TABLE IV.—FINAL TEMPERATURE OF AIR WHEN ENTERING HEATER AT 0 DEGREES.—TEMPERATURE OF STEAM IN HEATER, 227 DEGREES.—VOLUME OF AIR MEASURED AT 70 DEGREES.

Velocity, feet per minute.	Number of sections heater is deep.					
	1.	2.	3.	4.	5.	6.
1,600	26.5	51.0	74.9	94.7	111.3	125.2
1,500	28.1	52.4	76.3	95.8	112.4	126.0
1,400	29.5	53.8	77.2	76.7	113.3	126.8
1,300	31.1	55.0	77.6	97.9	114.3	127.7
1,200	32.4	56.4	79.6	99.0	115.3	128.7
1,100	34.0	57.7	80.5	100.0	116.2	129.6
1,000	35.6	59.1	82.0	100.1	117.2	130.5
900	36.9	60.1	83.0	102.1	118.0	131.3
800	38.5	61.6	84.3	103.1	119.0	132.3

TABLE V.—FRICTION LOSS IN INCHES OF WATER DUE TO THE SECTIONS.—VOLUME OF AIR MEASURED AT 70 DEGREES.

Velocity, feet per minute.	Number of sections heater is deep.					
	1.	2.	3.	4.	5.	6.
1,600	0.236	0.288	0.416	0.543	0.672	0.800
1,500	0.207	0.253	0.366	0.477	0.590	0.703
1,400	0.180	0.220	0.318	0.415	0.514	0.613
1,300	0.156	0.190	0.274	0.358	0.443	0.528
1,200	0.133	0.162	0.234	0.306	0.378	0.450
1,100	0.111	0.136	0.197	0.257	0.318	0.378
1,000	0.092	0.112	0.162	0.212	0.262	0.312
900	0.074	0.091	0.132	0.172	0.212	0.253
800	0.059	0.072	0.104	0.136	0.167	0.200

XUM

Table IV shows the final temperature of air entering the heater at a temperature of zero degrees when the temperature of the steam in the heater is 227 degrees, corresponding to a pressure of steam of 5 lb. by the gauge.

Table V shows the friction loss, or resistance to the flow of air through a heater made of these sections, for different velocities of air in feet per minute.

In all of these tables the volume of the air is measured at 70 degrees, and the velocity of the air passing through the heater is obtained by dividing the volume measured at 70 degrees by the free area of the heater. The free area is approximately 50 per cent. of the gross area.

Certain questions and suggestions relating to our first report presented at the January, 1908, meeting will receive due attention when our final report is made up for the consideration of the Committee on Standards.

WM. G. SNOW, *Chairman,*
R. C. CARPENTER,
J. H. KINEALY,
F. R. STILL,
J. H. BRADY.

Committee on Fan-blast Heating.

Mr. West: I should like to ask Mr. Snow if Mr. Childs gave any data as to the spacing of the pipes. In other words, any data from which we could get the number of square feet of heating surface per square foot of area, otherwise I do not see how the table could be of very much value, because the temperature rise through a coil or series of coils depends as much on the number of square feet of heating surface per square foot of area as it does on the number of coils, and while these curves would be very valuable for this particular heater if we knew what the heater was, I do not see how they can be very valuable otherwise.

Mr. Snow: He speaks of standard types of pipe heater where the pipe spacing is relatively close. Those familiar with that class of heater would interpret that statement to mean a spacing ranging from perhaps 2⅛ to 2¾ inches.

Mr. West: As I understand it that means a clear area ranging from 25 per cent. to 50 per cent.

Mr. Snow: I think I can state without being very far from

the mark that the free area is probably in the neighborhood of 40 per cent. of the gross area.

This paper is printed verbatim from the original article that was prepared by Mr. Childs, and is bringing out just the discussion we hoped it would. Speaking personally, I have no doubt I can secure from Mr. Childs the definite information which seems desirable and which the paper does not appear to contain. The questions brought up will enable the committee to secure further data along these lines.

President Mackay: Your point is well taken, Mr. West. You will understand that is simply a copy of Mr. Childs' article. Mr. Snow's committee have not the facts, but will undertake to get them and see that they are furnished.

Mr. West: I want to say in the beginning that I feel very grateful towards this committee for the valuable data which are being collected. I am, as I presume most of us are, finding good use for them. Ever since my first connection with the subject of fan blast heating I have been rather impressed with the fact that we never seemed to get down to a rational basis of figuring. Having checked over most of the data presented at both this and the preceding meeting I should say, that any part of these data may be used to practical satisfaction within the scope of the particular conditions for which they are adaptable.

There seems to be a lack of universal applicability, however, which limits each particular formula or table to a small field. This is no doubt due to the empirical treatment which the subject has thus far received.

I have just developed a rational formula covering the performance of indirect heaters. After having been checked against a number of tests, against the data presented here, and other existing tables, curves, etc., this formula seems to give promise of the basis for a more or less universal treatment of the subject.

The formula in its general form may be written:

$$R = K\frac{DZ^m N}{\sqrt[n]{V}},$$

and for all practical purposes, within the scope of present accuracy on the subject it may be written

$$R = 0.085\frac{DZN}{\sqrt[3]{V}} \quad . \quad . \quad . \quad . \quad . \quad . \quad . \quad (1)$$

Here R = rise in temperature of the air; K = a constant depending on the kind of heating surface; D = effective average temperature difference between the air and the steam

$$= \frac{T_1 - T_o}{\log_e\left(\frac{T_s - T_o}{T_s - T_1}\right)};$$

Z = the number of square feet of heating surface per square foot of clear area per unit depth of heater; m = a power applicable to (Z) and depending on the type of heating surface; N = number of units in depth of heater; V = velocity of the air at 70 degrees Fahr. in feet per minute through the clear area; n = a root applicable to V and depending on experiment.

The primary endeavors connected with the development of this formula were to get away from the idea of having it applicable to one make or type of heater only, and to have it adaptable to all conditions of temperatures and velocities.

No two heaters of different makes give anything like the same temperature rise to the air for the same number of pipes in depth of heater and equal air velocities.

The temperature rise depends as much upon the number of square feet of heating surface per square foot of clear area per unit as it does upon the number of units in depth of heater.

A factor (Z) is introduced covering this, the same being equal to the square feet of heating surface per square foot of clear area per unit; and is made a multiplier of the number of units.

Another fact with which we are all more or less familiar is that the average temperature difference between the air and steam (for all points throughout the heater) depends not only upon the temperatures of entering air and steam but upon the temperature of the leaving air also.

A factor (D) is introduced to accurately comprehend this instead of using the temperature difference between entering air and steam, or between the average of the air extremes and steam.

The fundamental theory from which this formula was developed, therefore, is the basing of the temperature rise of the air on the number of square feet of heating surface per square foot of clear area through the radiator, rather than upon the

number of units in its depth. Another departure from common practice is in the introduction of the effective average of differences between the temperatures of the air and the steam as a factor, in place of either temperature difference between the entering air and steam, or the average air and steam.

The reasons for these departures are reasonable enough and are as follows: The square feet of clear area through the heater when multiplied by the velocity gives the volume of air to be heated. Since the number of heat units required for this is practically in direct proportion to the volume, it is likewise in direct proportion to the clear area. Therefore the temperature rise will be in direct proportion to the number of square feet of surface per square foot of clear area. Again, it is a well established fact that the B. T. U. transmitted per square foot of surface per hour are practically directly proportional to the difference in temperature between the steam and air. This applies to all portions of the heating surface, hence the average rate of transmission will be proportional to the effective average difference.

Also, since the temperature rise is proportional to this rate of transmission, it is in turn proportional to the effective average difference. The value for this effective average difference, D, as given above, may easily be deduced by the aid of calculus and has been used for years in the calculations for feed water heaters, which calculations are analogous to those for hot blast heaters.

It is believed that by the introduction of the above factors in the formation of the formulæ given we get the basis, at least, for a rational formula and it only remains to assign the proper values to K, m and n from experimental data.

Formula No. 1 has been plotted out and is shown on Plate No. 1.

On Plate No. 2 is shown a comparison between this formula and some contemporary data of a similar nature.

All curves on this latter plate are shown for 1,000 feet velocity, 0 degree Fahr. entering air and 5 lbs. steam pressure.

This sheet is self explanatory and shows a very close relationship between the rational formula curve and some of the others under the particular conditions selected.

These conditions represent approximate average heating

conditions and we would naturally expect all data of any value to check up more or less closely at these points.

Notwithstanding this, it is noted that some of the curves

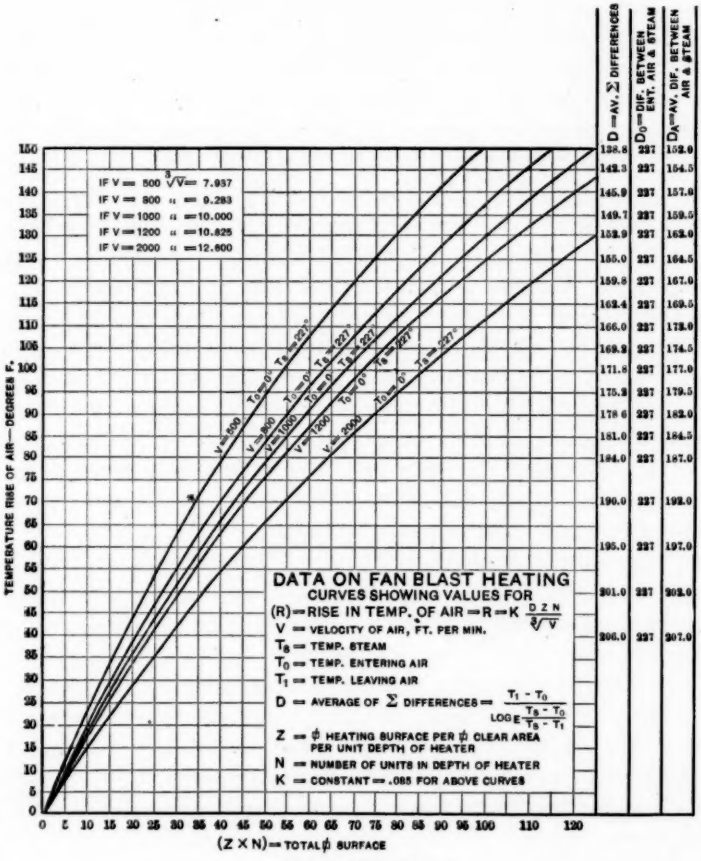

TEMPERATURE RISE OF AIR — DEGREES F.
(Z × N) = TOTAL φ SURFACE
D = AV. Σ DIFFERENCES
D0 = DIF. BETWEEN ENT. AIR & STEAM
DA = AV. DIF. BETWEEN AIR & STEAM
IF V = 500 ∛V = 7.937
IF V = 800 " = 9.283
IF V = 1000 " = 10.000
IF V = 1200 " = 10.625
IF V = 2000 " = 12.600
DATA ON FAN BLAST HEATING
CURVES SHOWING VALUES FOR
(R) = RISE IN TEMP. OF AIR = R = K D Z N / ∛V
V = VELOCITY OF AIR, FT. PER MIN.
T8 = TEMP. STEAM
T0 = TEMP. ENTERING AIR
T1 = TEMP. LEAVING AIR
D = AVERAGE OF Σ DIFFERENCES = (T1 - T0) / LOG E (T8 - T0)/(T8 - T1)
Z = φ HEATING SURFACE PER φ CLEAR AREA PER UNIT DEPTH OF HEATER
N = NUMBER OF UNITS IN DEPTH OF HEATER
K = CONSTANT = .085 FOR ABOVE CURVES

PLATE No. 1

show widely differing values even under these average conditions.

Attention is drawn to the close agreement between Curves I, II and III, and to the fact that Curves II and III represent the most recently developed and perhaps most accurate formulæ and data in use to-day.

Curve II is plotted from the formula presented by one of your members at the last annual meeting, and will be recognized at once as

$$R = \frac{I}{\sqrt[3]{V}}(T_s - T_o)\frac{I}{8/n + 0.24} \quad . \quad . \quad . \quad . \quad . \quad (2)$$

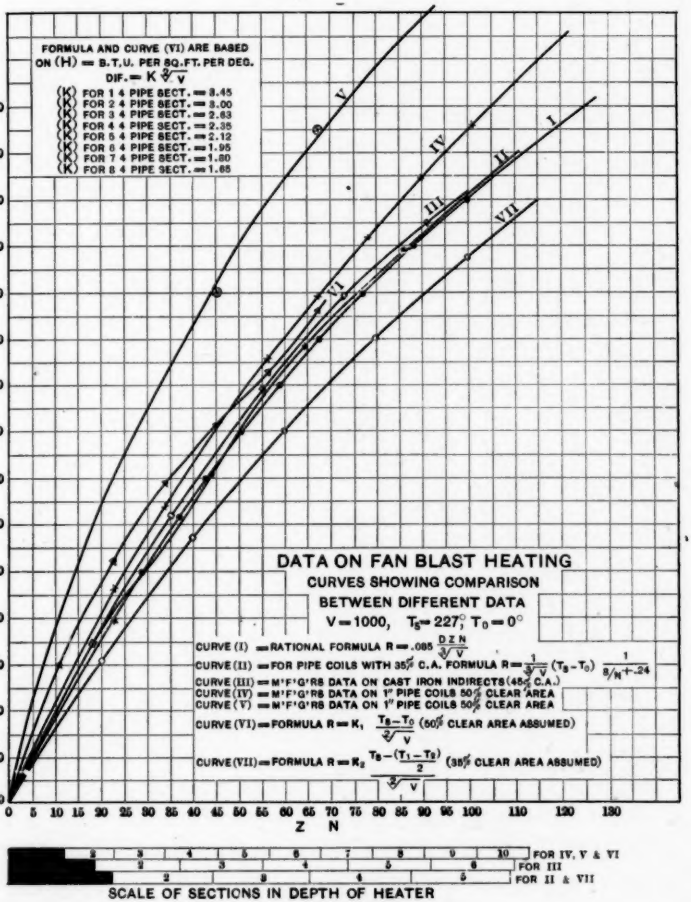

FORMULA AND CURVE (VI) ARE BASED ON (H) = B.T.U. PER SQ.FT. PER DEG. DIF. = K ∛V
(K) FOR 1 & PIPE SECT. = 3.45
(K) FOR 2 & PIPE SECT. = 3.00
(K) FOR 3 & PIPE SECT. = 2.63
(K) FOR 4 & PIPE SECT. = 2.35
(K) FOR 5 & PIPE SECT. = 2.12
(K) FOR 6 & PIPE SECT. = 1.95
(K) FOR 7 & PIPE SECT. = 1.80
(K) FOR 8 & PIPE SECT. = 1.65
DATA ON FAN BLAST HEATING
CURVES SHOWING COMPARISON
BETWEEN DIFFERENT DATA
V = 1000, Ts = 227°, To = 0°
CURVE (I) = RATIONAL FORMULA R = .085 DZN / ∛V
CURVE (II) = FOR PIPE COILS WITH 35% C.A. FORMULA R = 1/∛V (Ts - To) 1/(8/n + .24)
CURVE (III) = M'F'G'RS DATA ON CAST IRON INDIRECTS (48% C.A.)
CURVE (IV) = M'F'G'RS DATA ON 1" PIPE COILS 50% CLEAR AREA
CURVE (V) = M'F'G'RS DATA ON 1" PIPE COILS 50% CLEAR AREA
CURVE (VI) = FORMULA R = K, (Ts - To)/∛V (50% CLEAR AREA ASSUMED)
CURVE (VII) = FORMULA R = K2 (Ts - (T1 - T2)/2)/∛V (38% CLEAR AREA ASSUMED)
Z
N
FOR IV, V & VI
FOR III
FOR II & VII
SCALE OF SECTIONS IN DEPTH OF HEATER

PLATE No. 2

Where v = velocity of air in feet per second; n = number of 1-inch pipes in depth of heater.

Curve III is plotted from the data recently given out by a reputable concern covering the performance of cast-iron heat-

ing surface and checks up very closely with data of the same nature presented by your Committee at this meeting.

These two curves, which agree with the rational curve so closely under the conditions named, have their limitations, however, and I think a word might be said concerning this and

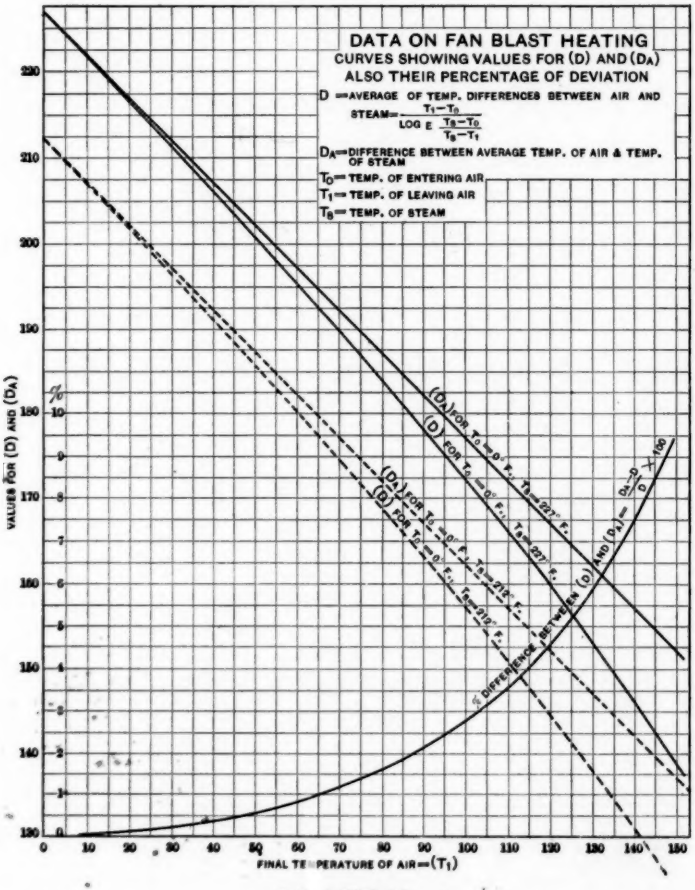

DATA ON FAN BLAST HEATING
CURVES SHOWING VALUES FOR (D) AND (D_A)
ALSO THEIR PERCENTAGE OF DEVIATION
D = AVERAGE OF TEMP. DIFFERENCES BETWEEN AIR AND STEAM = $\frac{T_1 - T_0}{\text{LOG E } \frac{T_S - T_0}{T_S - T_1}}$
D_A = DIFFERENCE BETWEEN AVERAGE TEMP. OF AIR & TEMP. OF STEAM
T_0 = TEMP. OF ENTERING AIR
T_1 = TEMP. OF LEAVING AIR
T_S = TEMP. OF STEAM
VALUES FOR (D) AND (D_A)
FINAL TEMPERATURE OF AIR = (T_1)
% DIFFERENCE BETWEEN (D) AND (D_A) = $\frac{D - D_A}{D} \times 100$

PLATE No. 3

the shortcomings of some of the other data cited so as to present more clearly, if needs be, the necessity of some more accurate basis of figuring.

In Formula II, if we keep all conditions constant except the

velocity, V, we get results varying directly as $\frac{1}{\sqrt[3]{\ }}$. This would represent actual conditions only on the assumption that the average temperature difference between the air and the steam remained constant. This cannot occur, however, owing to the changes in R due to changes in velocity. The formula is an empirical one, therefore, which, while apparently correct for average conditions, will show undue variations for all others.

Curves III, IV and V are made up from manufacturer's tables and are rather outside of this discussion except for comparison. Some of these data evidently need revision badly.

Formula VI and VII embody the same fault as Formula II, although in Formula VII this is somewhat ameliorated by using the average temperature of the air in place of the entering temperature of the same. Plate No. 3 will show the error to be expected from this. Besides this the two last formulæ embody another more serious defect as follows: K is a constant depending on the kind and type of radiation, on the number of units in the depth of the heater and on the velocity of the air. It has a number of values, therefore, each corresponding to a certain combination of the above-mentioned variable factors. For any purposes, except approximations of the very crudest nature, it is necessary not only to have a series of values for K corresponding to each kind and type of radiator, but that each series of such values shall cover all possible combinations between the number of units in depth of heater and the various air velocities.

It is a common occurrence to see this formula given with a table of values for K, depending solely on the number of units in depth of heater. In many such instances the kind of type of radiator is not referred to. When this last factor is omitted, it is, of course, folly for one to use the formula. This can be best appreciated by reference to any reputable heater tables, where it will be seen that almost twice the number of standard 1-inch pipe coil sections are required for the same temperature rise with 50 per cent. clear area coils as with 35 per cent. clear area coils. As to the variations in K, due to changes in V, very little or no stress is placed upon this, as far as I am able to learn from the public records of the formula. As a matter of fact, I have nowhere been able to find the factor mentioned.

The rational formula, if equally applicable to all ratios between heating surface and clear area and to all temperature and velocity conditions, eliminates at once these faults of the

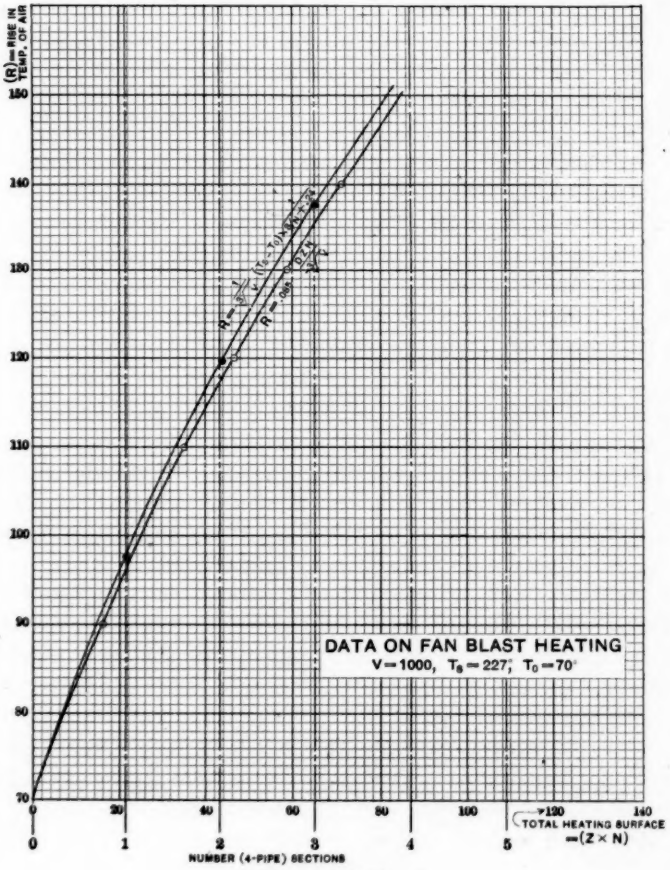


PLATE No. 4

empirical formulæ, which limit these latter to a certain set of conditions.

It would only remain then to assign the proper value to K corresponding to the kind of heating surface and we have a formula suitable for any case.

It is obvious that the uses of such a formula are manifold.

For instance, it is frequently necessary to reheat air for certain rooms and spaces, after it has been previously heated to the temperature to be used throughout the remainder of the building.

In such cases formulæ adaptable to ordinary conditions only will not apply.

It may be said, in connection with formula No. 2, however, that it agrees very closely with the rational formula under such conditions. Plate No. 4 shows a comparison of the two curves with entering air at 70 degrees Fahr.

Mr. Barwick: I should like to ask Mr. West what the basis of the upper curve (curve (V), plate No. 2) is as far as the free area between the pipes is concerned; whether he has considered that.

Mr. West: The free area through the pipes here is approximately 50 per cent. The free area through the coils for curve (IV) is approximately 50 per cent. The free area through curve (III) is 45 per cent., and the free area through curve (II) is 35 per cent. So as I said before, within the scope of the present accuracy of figuring out heater coils, it does not seem that power of Z would cut any figure as to the temperature rise. In other words, we must get the temperature rise down to a little closer basis before we can put any power on Z. I should just like to add, and I think it is partly shown in this paper presented to-night, that the scheme of using the average temperature between steam and air instead of the temperature between the entering air and steam is a good one, and it is along the line of these curves.

President Mackay: We will pass on to the report of the Committee to Collect Data on Hot Water Heating for Residences. Mr. Capron is not here, and Mr. Lewis, a member of the committee, will read the report.

Mr. Lewis presented the report, which had been printed in pamphlet form and mailed to members previous to the meeting. The report was discussed by Professor Carpenter and Messrs. Macon, Seward, Lewis and President Mackay.

XUM

FINAL REPORT OF THE COMMITTEE TO SECURE DATA ON HOT-WATER HEATING.

AMERICAN SOCIETY OF HEATING AND VENTILATING ENGINEERS.

After three preliminary reports to the Society, in which were submitted, first, a plan of procedure; second, replies to questions sent out; third, the result of tests made, the Committee beg leave to submit as a final report the accompanying notes, which are from the following sources:

Text-books and publications of prominent engineers.

Practice of engineers and contractors as shown by some sixty replies to letters asking for data.

Experience of and tests secured by the Committee.

Study and comparison of trade catalogues and information given by manufacturers.

DIRECT RADIATION:

The best practice calls for the use of the heat unit as a basis for computing the amount of radiation required.

TABLE A.*

Within the ordinary range of temperature, the losses in B. T. U. per sq. ft. per hour through various substances as given below, seem to be conservative.

Temperature outside	40	30	20	10	0	−10	−20
" inside	70	70	70	70	70	70	70
8-inch brick wall	13	18	22	27	31	36	40
12 " " "	10	13	16	20	23	26	30
16 " " "	8	10	13	16	19	22	24
20 " " "	7	9	11	14	16	18	20
24 " " "	6	8	10	12	14	16	18
Single window	36	49	60	73	85	93	105
Double "	24	32	40	48	56	62	70
Single skylight	31	42	52	63	73	84	94
8-inch frame housewall plastered inside	8	10	13	16	19	22	24
Cold floor areas, approximated by the committee from tests of rooms over open porches	5	6	8	10	11	13	15

The heat lost through surfaces exposed to cold may be found by using the above multipliers. The result should be increased by 30 per cent. as an allowance for leakage; or in rooms with three or four sides exposed, the leakage may be assumed as ordinarily not exceeding one change of air per hour, and the B. T. U. lost in this way may be determined as follows:

$$\frac{C \times T}{55} = \text{B. T. U.}$$

C = contents of room; T = temperature desired.

* With the exception of the last item this table is from the "Cyclopedia of Engineering" of the American School of Correspondence.

Fifty-five is approximately the number of cubic feet of air raised one degree by one B. T. U.

The glass area should be deducted from the exposed wall area before multiplying. The table is for southern exposure. Additions should further be made as follows for ordinary conditions: North, 25 per cent.; northwest, 30 per cent.; northeast, 20 per cent.; east, 10 per cent.; southeast, 5 per cent.; west, 25 per cent.; southwest, 15 per cent. The radiation on any side toward which there is an especial chance for strong wind to blow must be increased from 10 to 20 per cent. In the above additions northwest wind is assumed as most prevalent. To design any heating apparatus intelligently the points of the compass and surrounding conditions must be known.

The total B. T. U. as obtained above, after additions for leakage and exposure have been made, is to be divided by 150 for hot-water heating, as this is a conservative estimate of the amount of heat given off per hour by one square foot of ordinary cast-iron radiation with the room at 70 degrees and the water at an average temperature of 170 degrees. The quotient is the amount of direct radiation needed.

INDIRECT RADIATION:

The amount of indirect radiation required may be worked out by assuming the following:

The values shown in parenthesis are probably correct with indirect hot water.

Temperature of the air entering the room (110 degrees).

Average temperature of the air passing through the radiator (55 degrees).

Temperature of the air leaving the room (70 degrees).

Velocity of the air passing through the radiator (240 feet per minute).

Having found the loss of heat by exposure, to find the cubic feet of air necessary to carry this to the room at the given temperature:

$$\frac{H \times 55}{T - t} = \text{cubic feet of air per hour.}$$

H = exposure loss in B. T. U. per hour; T = temperature of the air entering the room; t = temperature of the air leaving the room.

Given this volume of air to find the heat necessary to raise it to the entering temperature:

$$(T - t)\frac{T \times C}{55} = \text{Heat.}$$

T = temperature required; t = temperature of the air entering the radiator; C = cubic feet per hour.

The amount of radiation is found by dividing the total heat by the efficiency of the radiation at the velocity and temperature difference assumed.

TABLE B.

The following table gives the emission of heat by indirect radiators per square foot per hour per degree difference in temperature:

Velocity of Air in feet per minute.	British Thermal Units.
174	1.70
246	2.00
300	2.22
342	2.38
378	2.53
400	2.60
428	2.67
450	2.72
474	2.76
492	2.80

The difference between 170 degrees (average temperature of the water in the radiator) and 55 degrees (average temperature of the air in the radiator) being 115, the efficiency at 240 feet velocity per minute is 2. per degree difference or 230 B. T. U.

Ordinarily the amount of indirect radiation required is computed by adding a percentage to the amount of direct radiation and an addition of 50 per cent. has been found sufficient in many cases; but in buildings where a standard of ventilation is to be maintained, the above formula seems more likely to give satisfactory results. Free area between the sections of radiation to allow passage of the required volume of air at the assumed velocity must be carefully maintained. The cold-air supply duct, on account of less frictional resistance, may ordinarily have 80 per cent. of the area between the radiator sections. The hot air flues may safely be proportioned for the following air velocities per minute: First floor, 200 feet; second floor, 300 feet; third floor, 400 feet.

Boilers:

Many boilers for residence heating are not rated satisfactorily in the catalogues. Among twelve familiar types the hot-water rating for the same grate surface varies from 2,800 to 3,875 square feet. The amount of heating surface is not generally pub-

lished and information is difficult to obtain. It probably varies 50 per cent. among these same twelve types.

Given proper combustion and sufficient length of fire travel to prevent excessive draft, the amount of heating surface is apparently not a prime factor, as boilers with large combustion chambers and comparatively small heating surface have surpassed the performances of other boilers of the same type and grate area with small combustion chambers and large heating surface.

A restricted combustion chamber is kept at rather a low temperature by the proximity of the water-cooled surfaces and the high temperature of good combustion is difficult to obtain. As a rule, the longer and higher the fire-box the better the combustion.* Apparently 8,000 B. T. U. per lb. of coal is a conservative average estimate of the heat transmitted to the water in a well-designed boiler, after allowances for various causes commonly affecting the efficiency have been made. Hard coal usually gives off more heat per pound than soft coal, but on account of the more rapid combustion of soft coal the final results of the two fuels about balance. Thus, if we divide the heat given off per hour by the radiation and piping by the effective value of the coal, we have an estimate of the pounds of coal that must be burned per hour.

The grate surface to be provided depends on the rate of combustion, and this in turn depends on the attendance and draft, and on the size of the boiler. Small boilers are usually proportioned with a small amount of heating surface per unit of grate, and thus are adapted for intermittent attention and a slow rate of combustion. The larger the boiler, the more attention is given to it, and the more heating surface is provided per square foot of grate. The following rates of combustion are common for Internally Fired Heating Boilers:

TABLE C.

Sq. ft. of Grate.	Pounds of Coal (Hard) per sq. ft. per hour.
4 to 8	Not exceeding 4 pounds.
10 to 18	" " 6 "
20 to 30	" " 10 "

The number of pounds of coal to be burned per hour divided by the rate of combustion indicates the size of the grate required.

* Wm. G. Snow in "Principles of Heating." Some authorities give as high as 10,000 B. T. U. for hard coal. In the judgment of the committee it is wise not to calculate on over 8,000 B. T. U. for small internal fired boilers.

It is desirable so to proportion residence boilers that attention need ordinarily be given them only about once every eight hours. The fire-box should be sufficiently large to hold this amount of coal with its attendant ash and clinker and still leave ample room for the mixture of the products of combustion.

Multiplying the amount of coal required per hour by the number of hours intervening between replenishments and adding 20 per cent. for ash and clinkers gives a conservative estimate of the number of pounds of coal to be accommodated. This divided by 50, the number of pounds of ordinary coal in one cubic foot, gives the space occupied by the fuel. As this should not exceed about one-third of the total height of the fire-box for soft coal, this sum multiplied by three gives the fire-box capacity in cubic feet for soft coal. Multiplying the fuel space by two is believed to give ample combustion space for hard coal. Combustion must be completed in the fire-box of the ordinary boiler or it is never completed. The flues are merely economizers acting to cool down the products of the combustion before entering the chimney.

WATER HEATERS.

The use of steam coils in a tank or feed-water heater for heating water to supply hot water radiation is common, and because of the rapid circulation and ease of regulation gained is often desirable.

Having determined the amount of hot water radiation, to find the square feet of brass piping in a tank necessary to heat the water to the desired temperature:

$$\frac{R \times X}{(S - W)\ 95} = \text{sq. ft. brass pipe surface.}$$

R = hot water radiation; X = B. T. U. given off per hour by 1 sq. ft. of radiation (150 for direct, and 230 for indirect at 170 degrees); S = temperature of the steam (depending on pressure used); W = temperature of the water. 95 is the approximate B. T. U. given off by 1 sq. ft. of brass coil per degree difference per hour. Allowance must be made liberally for mains and tank radiating surface.

PIPING.

Too much cannot be said as to the importance of reaming the piping for hot-water work. All piping and nipples should be

reamed slightly larger than the inside diameter. The amount of water of a certain temperature required per hour by radiation may be determined by the following formula:

$$\frac{R \times X}{20 \times 60.8 \times 60} = \text{cu. ft. of water per minute.}$$

R = square feet of radiation; X = B. T. U. given off per hour by one square foot of radiation (150 for direct and 230 for indirect) with water at 170 degrees. Twenty is the drop in temperature in degrees between the water entering the radiation and that leaving it: 60.8 is the weight of a cubic foot of water at 170 degrees: 60 is to reduce the result from hours to minutes.

The average sizes of mains, as used by seven prominent engineers in regular practice for 1,800 square feet of radiation, are given below:

2 Pipe	open tank system,	100	ft. mains	5	in. pipe	= 26.6	ft. velocity per minute.				
1 "	"	"	"	100	"	"	6	"	"	= 18.4	"	"	"	"
Overhead	"	"	"	100	"	"	4	"	"	= 41.8	"	"	"	"
"	"	"	"	100	"	"	3	"	"	= 72.1	"	"	"	"

For 1,200 square feet indirect radiation with separate main, 100 feet long, direct from boiler, open system, the bottom of the radiator being 1' 0" above the top of the boiler—5" Pipe=22.4 feet velocity per minute.

The following is taken from "Principles of Heating," by Wm. G. Snow:

"If the volume of water passing through pipes of different sizes is known, the radiating surface they will supply may be readily computed. With the same drop in temperature in radiators, the force causing circulation will be alike in all. With pipes of equal length, the resistance will vary, as the square of the velocity and inversely as for the diameter expressed as $\frac{V^2}{d}$. Now, if we assume, for example, that a 2-inch pipe will supply 200 square feet of direct radiation, which in practice it will readily do, and compute the value of $\frac{V^2}{d}$, then make $\frac{V^2}{d}$ the same for pipes of other sizes, a table may be prepared showing the radiating surface that may be supplied by pipes of different diameters when working under the same conditions, with respect to the head causing the flow and the resistance to the circulation."

As the velocities stated agree with the practice of the seven engineers above tabulated for a two-pipe open system, the following table has been prepared, using Mr. Snow's table as a

basis, and changing the amounts of radiation supplied under other conditions in proportion as these given by him vary for other sizes of pipe. The amount used as a base in each column is in heavy type.

TABLE D.

The capacity of mains 100 ft. long, expressed in the number of square feet of hot-water radiating surface they will supply, the radiators being placed in rooms at 70° Fahr., and 20° drop being assumed.

Diameter of Pipes.	Two-Pipe up Feed Open Tank.	One-Pipe up Feed Open Tank.	Overhead Open Tank.	Overhead Closed Tank.	Two-Pipe Open Tank.
Inches.	Direct Radiation.	Direct Radiation.	Direct Radiation.	Direct Radiation.	Indirect, 12 inches above boiler.
1¼	75	45	127	250	48
1½	107	65	181	335	69
2	**200**	121	339	667	129
2½	314	190	533	1,060	202
3	540	328	916	**1,800**	348
3½	780	474	1,334	2,600	502
4	1,060	645	**1,800**	3,350	684
5	1,860	1,130	3,150	6,200	**1,200**
6	2,960	**1,800**	5,000	9,800	1,910
7	4,280	2,700	7,200	13,900	2,760
8	5,850	3,500	9,900	19,500	3,778

The capacities of risers for different floors, from data obtained from nine engineers, in the same manner, agree almost exactly with Mr. Snow's table given below for an open tank system. The table for an overhead closed tank system is proportional to Mr. Snow's table for mains, using as a basis 300 square feet of radiation on a 2-inch riser.

TABLE E.

The capacity of risers expressed in the number of square feet of direct hot-water radiating surface they will supply, the radiators being placed in rooms at 70° Fahr. and 20° drop being assumed:

Diameter of Riser.	Open Tank System.				Closed Tank Overhead System.
Inches.	1st Floor.	2nd Floor.	3rd Floor.	4th Floor.	Drop risers, not exceeding 4 floors.
1	33	46	57	64	48
1¼	71	104	124	142	112
1½	100	140	175	200	160
2	187	262	325	375	300
2½	292	410	492	580	471
3	500	755	875	1,000	810

All horizontal branches from mains to risers or from risers to radiators, more than 10 ft. long (unless within 15 ft. of boiler), should be increased one size over that indicated for risers in the above table.

Inasmuch as radiators are commonly tapped 1 inch up to 40 square feet, 1¼ inches from 40 to 72 square feet, and 1½ inches for larger than 72 square feet, little is to be said about the size of radiator connections. One prominent engineer states that with one pipe overhead circulation he has never found a radiator so large that 1½-inch connection would not supply it.

The following hints from an engineer of wide experience may be of aid:

FEED MAINS.—When the radiators are all on the same level, those branches within 10 to 15 ft. of boiler are taken off the side of the main. When, however, there are any second- or third-floor radiators, with branches within 10 or 15 ft. of boiler, these branches are taken off the side of the main, and all first-floor branches are taken off at 45 degree angle.

RETURN MAINS.—All return branches run into side of main regardless of their length. All returns within 10 or 15 ft. of boiler run separately to bottom of boiler instead of joining main return, so as not unduly to heat the drop in the return main.

Pitched fittings should be used instead of crooked threads at all connections between horizontal and vertical pipes.

Another states that he has been using with perfect satisfaction special radiator tappings side by side at the bottom of one end of each radiator. This results in economy of installation and a neater appearance of the work.

E. F. CAPRON, *Chairman.*
S. R. LEWIS.
CHAS. F. NEWPORT.
} *Committee on Hot-water Heating.*

DISCUSSION.

Prof. R. C. Carpenter: No one can appreciate more than I do the difficulty which is involved in preparing a report of practice on any branch in the heating art, and for that reason I trust that what I say will not be considered as a criticism.

It will be noted that this report is, like several others which have been submitted to the Society, based on the results of various natural laws, and the calculations given in the report are made on the assumption that such laws are correct. Such being the case it strikes me that no set of figures or coefficients should

be stated unless they are universally accepted or unless the source and authority from which they were derived are given.

On the first page of this report are given some coefficients for heat transmission which are different from any that I have heretofore seen, and no statement is made as to the experiments or authority from whom these coefficients were obtained. I have spent considerable time in trying to get together all the reliable experiments giving heat transmissions from buildings and have tried to trace reliable data of that kind to a responsible authority. I have given these results in my book on Heating and Ventilating. I also had a special paper on the subject before this Society.

The results of this investigation indicate that all the reliable data which we have on this subject are founded on Peclét's experiments. These have come to us through various channels and from both the English and the German. In some cases these results have been modified somewhat but not, so far as I can ascertain, by any new experimental data. If our committee have been to the labor of making new experiments along this line, I think the Society certainly should have the chance to discuss such experiments and to consider the relative accuracy as compared with Peclét's results.

On page 8 it is stated that 8,000 B. T. U. per pound of coal is a conservative estimate of the heat transmitted to the water in a well-designed boiler. I think the authority for that statement should also be given. On some tests which I have made of steam boilers, in which good anthracite coal was burned at a rate not exceeding 4 pounds per sq. foot. of grate per hour, this number is low and does not fairly represent the efficiency which can be expected. With good selected anthracite coal of domestic sizes, my tests indicate that about 10,000 B. T. U. are available. I would agree, however, with the statement in the report if soft coal is to be included as well as hard, but I think the report should specify the conditions more definitely.

The statement respecting the amount of coal burned per sq. foot of grate per hour, given on page 5, agrees very closely with my experience as to the basis of rating, but I should like to see a fuller discussion because I find that many of the boiler makers are estimating that even small boilers with less than 8 sq. ft. of grate are carrying considerably more radiation than

is possible from the combustion of 4 pounds of coal per square foot of grate per hour.

As an illustration in the catalogue of a prominent boiler company a boiler supplied with a grate 18 in. diameter is rated for 575 sq. ft. of radiation. This is equivalent to 1.76 sq. ft. of grate. If it were to burn 1 pound of coal per sq. ft. per hour and utilize 10,000 B. T. U. per pound, 17,600 B. T. U. would be absorbed by the steam. Good efficient steam radiation will usually deliver, under working conditions, 250 B. T. U. per sq. ft. per hour. By computation it would appear that on this basis 1 pound of coal per sq. ft. of grate per hour would supply 70.4 sq. ft. of total radiation. If 4 pounds are burned per sq. ft. per hour, which from my experience is a reasonable amount, 281.6 sq. ft. of radiation would be supplied.

My experience indicates that a good deal of the radiating surface is sold as having a greater area by 10 to 20 per cent. than it actually possesses, and this radiation is often constructed or arranged in such a manner as to be quite inefficient. It is probably fairly safe to assume that with such radiation the heater would have 20 per cent. greater capacity than with more efficient and full-sized radiation. In this case the total radiation carried might approximate 340 sq. ft. From my basis of calculation the boiler referred to would have to burn over 8 pounds of coal per sq. ft. of grate per hour in order to carry the rating of the catalogue.

I sincerely hope that before this report is taken away from the committee they will give consideration to various matters to which I have referred, as it is at once obvious that the basis of all scientific design must rest on accurate coefficients which are based on accepted experiments by well known authorities and must not depend upon estimates or guesses made by practical men.

The committee replied to Professor Carpenter's remarks as follows:

The authority for the coefficients in Table A in the report is the Cyclopedia of Engineering of the American Correspondence School, vol. 2, page 426. See foot-note under the table.

After considerable further investigation and the discussions at the last annual meeting we believe that it is hardly safe as a basis of calculation to consider a pound of hard coal as giving

off more than 8,000 B. T. U. when burned in a small boiler, such as is considered in residence heating.

Mr. Lewis: Our preliminary report shows a large number of direct radiation formulas. We were appointed to secure data of common practice and we have not attempted to make extremely accurate computations or write a text-book. After a good deal of inquiry and from our own experience we believe, notwithstanding the tests which show the utilization of as much as 10,000 B. T. U. per lb. of coal, that we should not base our computations on over 8,000 B. T. U. per lb.

Mr. Macon: I have here the report of tests made under the jurisdiction of the U. S. Geological Survey, of the sectional boiler and the vertical boiler at the University of Illinois. On the sectional boiler they made altogether nineteen or twenty tests with Pocahontas coal averaging very nearly 15,000 B. T. U. per pound. They got an efficiency of 55 per cent. which is equal to 8,250 B. T. U. That was the best result they got in efficiency. I think that, perhaps, the tests so far as I have been able to find out would hardly satisfy the heating engineers because they operated the boilers the way they would conduct the test of a steam boiler: *e.g.*, I notice there are intervals between firings of sometimes an hour and sometimes two hours, and, yet, I should think one would get a better efficiency this way than firing every eight hours. With Pocahontas coal they got 55 per cent. and with coke 61 per cent. The coke only run 12,076 B. T. U. per pound. With anthracite they got 59 per cent., averaging 12,680 B. T. U., which is equal to 7,481 B. T. U. utilized per pound. It is singular that these tests of the Government vary so much from the figures Professor Carpenter states, 10,000 B. T. U.

Mr. Seward: These tests were made with a very large flue. On one of these tests the grate area is about 4 sq. ft. with 1 sq. ft. of chimney area. That was a round boiler. They ran those tests to determine the relative heating value of coal with particular reference to Illinois soft coal. In addition to running these efficiency tests they also ran other tests to determine the efficiency of varying rates of combustion. They started as low as 1.5 pounds of coal per sq. ft. of grate per hour and ran up to 8, or when they got the full rating of the boiler. The highest efficiency they could get according to those tests in the sectional

boiler was 58 per cent. and in the round boiler 51 per cent. The tests are very complete and, as published by the Geological Survey, make very good reading.

President Mackay: This paper brings out the point of rating boilers, and we have decided to run that with the other topic, the report of the committee on heating boilers, Professor Kinealy, Chairman. He is not here, and I do not understand we have a report from that committee. We have a short paper by Professor Kent and one from Mr. Seward on that subject. I propose we have this one read by Mr. Macon (Professor Kent's paper) and let Mr. Seward read his, and have the discussion on the two papers together.

Mr. Macon read Professor Kent's paper, and Mr. Seward read his paper.

The papers were discussed by Messrs. Hale, Kinealy, Seward, Nichols, Snow and Weinshank.

President Mackay: It seems to be my lot to appoint the committee in charge of the review meeting. I do not like to do it because it seems my name is on it. The committee should read this way: Messrs. Snow, President-elect, Hoffman, of Lafayette, Ind.; Harrison, of New York; Chew, of New York, and ex-President Mackay, of Chicago.

The committee's duties are to arrange details for a review meeting.

Mr. Chew: No; to submit a plan for conducting a review meeting before this meeting adjourns. My motion was the committee should consider the matter and make a report before we adjourn, so the Society can see whether it suits them or not, and not that we wait a year or six months.

President Mackay: We are about to adjourn and want to meet promptly at two o'clock. (Adjourned.)

Second Day—Afternoon Session.

(Wednesday, January 20, 1909.)

The convention was called to order at 2.30 P.M. by President Mackay:

President Mackay: Before going on with the regular business I wish to announce that arrangements have been made

to visit the Singer Building. Mr. Barwick will see that you are provided for.

Last evening we were under the head of committees' reports and the question of rating boilers. We had three papers which were read and the discussion was not terminated. Professor Kinealy is here, Chairman of the Committee on Data on Surfaces in Heating Boilers, who has a report to submit at such time as we are ready.

I find on the desk a communication with reference to the fire at Collinwood School, near Cleveland, Ohio. It seems to draw to our attention the fact that the fire did not originate from the heating apparatus.

Mr. Lewis moved the communication be read, which was seconded and agreed to.

The following communications were read by Secretary Mackay:

Extract from Report of H. T. Brockman, Assistant Fire Marshal of Ohio.

File Case G, 969, State Fire Marshal's Office.

Fire occurred at 9.30 A.M., March 4th, '08.

CLEVELAND, O., March 6, 1908.

To J. P. BRENNAN, First Deputy, Columbus, O.

DEAR SIR: Mr. Feigenbaum and I went to Collinwood early yesterday morning with a view to determining, if possible, the cause of the calamity which occurred the day before.

* * * * * *

Mr. Hiter, the janitor, is positive that the fire started in the store room immediately beneath the stairs. This theory is not well supported, by reason of the fact that he claims to have had nothing in that room except a box of lime. The outer part of the box was burned but the inner part showed no traces of a fire. Chief Wallace, of the Cleveland fire department, and myself spent considerable time in a very close investigation of the burned building. The débris had been cleared and an inspection could be made at this time. Chief Wallace is of the opinion that the fire was due to imperfect installation of the heating plant. The plant in question was a low pressure cast iron boiler, of a type ordinarily used in these buildings, but the main steam pipe had been run through the wall, resting in part upon some joists or beams. His theory is that the constant and steady heat had caused the beams to become superheated, and that they had been burning for some considerable time before the smoke was discovered by the little Neubert girl. The asbestos covering of the pipe is of a very inferior grade, and appeared to be very largely composed of a cheap plaster which would not be fire resisting. This theory is thoroughly concurred in by Mr. Lougee (building inspector, Cleveland), who pointed out several serious defects for basing their conclusions as they have done. The beams immediately over

the boiler are the only ones that show traces of complete combustion. The ends of the beams still running into the wall burned right close up to the brick work. In every other part of the building the beams when falling had torn out of the brick work, leaving vacant spaces and no portion of the woodwork behind.

(Signed) H. T. BROCKMAN,
Assistant Fire Marshal of Ohio.

COLLINWOOD, O., January 2, 1909.

MR. A. W. WILLIAMSON,
President Midland Club, Cincinnati, O.

DEAR SIR: In answer to your inquiry in regard to the character of the heating apparatus used in Lake View School, Collinwood, O., where the fire occurred the fourth of March last, and where so many lives were lost, will state that:

(1) The heating apparatus used in the building was what is known as direct radiation steam heat supplied by two cast iron boilers of low pressure.

(2) There was no hot air furnace or other heating apparatus in the building.

I am making the above statement from positive knowledge, having been in the basement a great many times, both when the building contained only four rooms and was heated by one boiler, and after the additional four rooms were added and the second boiler installed to assist in their heating.

There were no hot air flues in the building at any point, and in my opinion the fire was not in any way caused by the heating apparatus.

I am now and have been for four years a member of the Board of Education of this village, and for the last four months have been its clerk.

Yours truly,

H. H. GAGE.

Mr. Lewis: I would like to say the building was in pretty good condition, and it is not a representative building of the type that is scattered around through the country. There are thousands of buildings in the United States that are infinitely more dangerous from fire than that building ever was.

Mr. McCann: In connection with this letter I would like to state that on low pressure heating plants it seems practically impossible for the steam pipes to start a fire in wood work. We have in some old school houses found steam mains run through snugly fitting holes bored through joists where they have been probably for thirty or forty years, under ordinary heating conditions, without even showing any charring of the wood.

The report of the Committee to Collect Data on Surfaces in Heating Boilers was then taken up and discussed by Messrs. Kinealy, R. C. Carpenter, Seward, Secretary Mackay, Keesler and Nichols.

XUM

Mr. Vrooman moved the matter be referred to the Committee on Standards, which was seconded and agreed to.

President Mackay: We will take up Air Cooling by Refrigeration, by W. W. Macon.

Mr. Macon presented the paper and illustrated it with diagrams on the blackboard. It was discussed by Messrs. Weinshank, Lyle and Lefman.

President Mackay: We will pass to the report of the Committee to Collect Data on the Relative Corrosion of Wrought Iron and Steel Pipe, Mr. T. N. Thomson, Chairman.

Mr. Thomson read the report and it was discussed by Messrs. Barwick and Paul.

President Mackay: The next paper is, Notes on the design of furnace heating systems with an application to a ten-room residence, by J. D. Hoffman.

Mr. Snow read the paper, and it was discussed by Messrs. Carpenter, Chew and Seward.

Mr. Snow then read a report of the committee on the review meeting, upon which the session adjourned.

Third Day—Morning Session.

(Thursday, January 21, 1909.)

The meeting was called to order by President Mackay at 10.45, who announced that the first matter on the programme was a paper: "Miniature steam traps and their application to steam circulation," by James A. Donnelly.

Mr. Oldacre presented the following motion, which was seconded by J. T. Bradley:

In view of the nature of this paper, which every one is familiar with and of the articles of the Constitution bearing thereon, it is a type of paper that will not contribute prestige or benefit to the Society or its members, and I move it be referred back to the Board of Governors, with instructions that it not form any part of our Proceedings.

Mr. Chew, as temporary Chairman of the special committee on legislation for New York State, presented the following report:

Your Special Committee on Legislation for New York State has been unable to meet in a body, but several of its members have prepared the appended letter, and with the instruction of the Society will send it to the Governor, the Senate, and House of Assembly of New York State.

Respectfully,

FRANK K. CHEW,
Temporary Chairman.

Believing that compulsory ventilation of certain factory buildings as provided for in section 86 of Article VI of the Laws Relating to Labor and Factories is essential to the health and sanitary welfare of the employees, the American Society of Heating and Ventilating Engineers, in annual meeting assembled, heartily indorses the provisions of the law.

FRANK K. CHEW,
R. C. CARPENTER,
W. C. VROOMAN,
W. M. MACKAY.

Topic No. 3, Air-cooling by means of air-washers, was then taken up for discussion. Secretary Mackay read a written discussion by Professor Carpenter, and it was further discussed by Messrs. Weinshank, Chew, Lewis, Badger and Secretary Mackay.

Topic No. 4, The relative carrying capacity of horizontal and vertical warm-air pipes, and Topic No. 5, The effect of shape on warm-air risers, were discussed by Messrs. Chew, Snow, Lewis, Vrooman, Schaefer and Austin.

Topic No. 6, The duty of the Society relative to informing the public of the lack of ventilation in halls and public gatherings, particularly in the thousands of store-rooms fitted up for moving-picture shows, was discussed by Messrs. Chew, Badger, Vrooman, McCann and Macon.

Topic No. 7, The necessity for having ventilation laws applying to the installation of apparatus in old as well as in new buildings, was discussed by Secretary Mackay and Messrs. Chew and Badger, Hall and Seward.

On motion of Mr. Chew, seconded by Mr. Badger, the President was requested to appoint a committee to frame and report a resolution covering Topics Nos. 6 and 7 and bringing them to the attention of the public. The President appointed as such committee Messrs. Lewis, Badger and Monroe.

Topic No. 8, State control for heating and ventilating engineers, was discussed by Secretary Mackay and Messrs. Badger, Kinealy, Donnelly, Vrooman, Seward and President Mackay.

XUM

On motion it was agreed to refer the subject to the legislative committee.

Secretary Mackay: I move that it is the sense of this meeting that the regular standing committees, Compulsory Legislation, Standards and Tests, be continued with such change of personnel as may be found desirable; and that the newly-elected President shall continue or appoint such special committees or fill vacancies in same as he may consider necessary in the best interest of the Society, and that such special committees as have completed their duties or are not considered necessary be discharged with the thanks of this Society.

President Mackay: There are certain committees necessary for our work and those we term "Standing Committees." There are other committees we know as "Special Committees" which have performed most excellent duties during the past. It is moved this action be taken upon this matter of committees.

The motion, being seconded, was agreed to.

President Mackay: I know of no committees but what should be discharged with thanks except those to whom special work has been assigned within the period of this session.

Mr. Snow: Certain committees have asked to be discharged and others feel their labors have not been completed, and the President wishes to be advised by the chairmen of these various committees whether or not they wish to be discharged—whether or not they consider their duties completed.

President Mackay: Agreeable to the terms of this motion I now wish to thank the special committees for the time and labor they have given in the discharge of their duties, and discharge them now. The work can be taken up by the new administration.

The session here adjourned.

Third Day—Afternoon Session.

(Thursday, January 21, 1909.)

The meeting was called to order by President Mackay at 2.15 P.M.

President Mackay: The first order of business is a paper,

entitled "The effect of wind on heating and ventilating," by H. W. Whitten.

Mr. Whitten read the paper, and it was discussed by Messrs. Kinealy, Donnelly and Monroe.

President Mackay: There was a committee appointed this morning and expected to report this afternoon. I would like to ask Mr. Lewis if he is ready to report.

Mr. Lewis presented the following report:

Resolved, That it is the duty of the American Society of Heating and Ventilating Engineers to call the attention of the public to the necessity of adequate ventilation in all old as well as new buildings where persons congregate, such as schoolhouses, factories, halls and theatres, and that a central publicity committee of three be appointed, represented and assisted by one member from each state, whose duty it shall be to make continued and persistent effort to educate the public mind and to disseminate literature and information to the press, to the law-making bodies, colleges or any other organizations or persons through whom it is possible that the aims of our Society toward proper ventilation may be advanced.

S. R. LEWIS,
O. L. BADGER,
E. K. MUNROE.

Mr. Snyder: I do not know of any movement undertaken by this Society which would have more far-reaching results or be of more importance than this. I believe a committee should be formed on publicity which might receive the title of Committee on Literature. The committee should be provided with a form of the regular proceedings, and report to this body a synopsis of the laws of the various States and the rules and regulations so far as can be obtained from the various authoritative bodies, to which there might be added observations of medical men and other authorities as to the necessity of ventilation. It should be brief and pointed, so that when it is received by any one at all interested it will be placed in their files for reference. All resemblance to a circular should be avoided.

President Mackay: The report will be handed to the Secretary and the committee discharged with thanks for their

labors. The new administration will be charged with the duty of proceeding along these lines.

Mr. Snyder: I would move that the President appoint a Publicity Committee of one member from each state where we have membership, working through a central committee of three members, with full power to carry out the wishes of the Society as expressed in the report just received.

President Mackay: My opinion is the motion is right, but we should not hamper the administration or tie their hands.

Motion seconded.

Mr. McCann: I understand there was a motion made this morning authorizing the incoming President to appoint such committees as he chose.

President Mackay: That is right. This is a departure in that line, and a departure in a direction in which we have been, in my humble judgment, somewhat weak on.

Secretary Mackay: In accepting the report of this committee the Society obligates itself to support the committee.

Mr. Snyder. Why not change that and simply make it conditional on the part of the incoming administration to make that suggestion should it see fit.

President Mackay: Does the supporter sanction that?

Mr. Lewis: I suppose I might make our thought a little more clear. Our idea was to publish something in reference to compulsory legislation, and that this would keep the matter stirred up in each State. There would be a man there who would be doing this. It would give us advertising as engineers that would further the end suggested in the discussion this morning as to State control of heating and ventilating engineers. It would be known all around that this Society of Heating and Ventilating Engineers was doing business right here all the time. These articles should appear in the trade press following on the necessity of ventilation. Possibly it would be wise to have some of the compulsory legislation committee on this committee, the two to work closely together.

President Mackay: That would be a matter for the incoming administration. You are in sympathy with Mr. Snyder's motion?

Mr. Lewis: Certainly.

Mr. Badger: I endorse most heartily the action of the Society this morning. We were instructed to draw resolutions along these lines. As a matter of fact the appointment of that committee rests with the incoming administration and the committee will now carry out the wishes of the Society as expressed in the resolution. I would like the Society to instruct the committee to carry out this work.

Mr. Snyder's motion was agreed to.

President Mackay: The report is accepted and the committee discharged with thanks.

Topic No. 9, The value of tabulated experience recognized as science compared with individual opinion and experience, was discussed by Messrs. Chew and Munroe.

Topic No. 10, A table of sliding scale of indoor and outdoor temperatures for gauging the capacity of heating plants to maintain a 70 degree temperature inside with the outside temperature at zero, this to be established by the Society so that it could be widely incorporated in heating specifications and add to the Society's prestige, was discussed by Messrs. Chew, Garwick, Secretary Mackay, Kinealy, Badger, Bishop.

Topic No. 11, The maximum permissible length for a steam main in a gravity apparatus operating under a pressure not to exceed two pounds on one and two-pipe systems, was discussed by Messrs. Barwick, Donnelly and Bishop.

The installation of the newly elected officers then took place.

Secretary Mackay read the list of the officers.

Mr. Seward and Mr. Bishop were appointed to conduct the newly elected officers to the platform, and began their duties with President-elect Snow.

President Mackay: (Addressing President-elect Snow.) It is my pleasure to announce that you have been elected President of the American Society of Heating and Ventilating Engineers for the ensuing year, and it is with great pleasure I turn the office over to you. I congratulate the Society upon the most excellent material they have selected. (Applause.)

President Snow: Mr. President and Gentlemen—I have received a number of words from members present this morning assuring me of their hearty coöperation in carrying on the

work. I shall take great interest in it I assure you, and will give you the best of my services during my term of office, and I feel sure that with the coöperation I shall receive from the association we shall have a successful year. I thank you for the honor you have conferred upon me. It will be a pleasure to serve you. (Applause.)

President Snow: I want to announce that immediately after the termination of this meeting there will be a meeting of the Board of Governors for organization.

Topic No. 12, The relative area of wet and dry return mains in a gravity steam heating apparatus, was then presented. It was discussed by Messrs. Monroe and Donnelly.

Mr. Chew: Heretofore we haven't carried out the suggestion made four or five years ago relative to a question box. I now make a motion that the Secretary be instructed to take the different questions that have been sent in from time to time, on a special question sheet, have each question printed on a separate sheet, a set of the sheets to be sent to every member of the Society some time during the year, possibly when these special reports are sent out, and in that way the questions which have been raised can receive the attention of the entire membership, instead of being passed over with scant consideration in discussion here. The members can take them up at their leisure or when their mind is on something of that nature during the year, and return to the Society sixty days before the next annual meeting. In that way we would get valuable information.

The next topic, No. 13, is a question, and it is changed from a question to make it a topic for discussion here, and when presented as a question as it first came to the Secretary's office it will certainly bring forth more intelligent treatment than it probably will have if discussed as a topic.

Mr. Barwick: I think if they were put in form when they are received or at certain stated times, say, every three months, and sent out to the members, we would get a great deal better results than we get at the present time on the floor. There is hardly time to discuss some of these things that come up. The same questions have been asked probably half a dozen times, and have been answered in one or two ways, but it does not make any difference how many times we ask a ques-

tion. We are bound to get some meat out of the subject. I feel it is a very good idea to send out these questions in advance of the meeting so that when we come to the meeting we are ready for some discussion on that subject.

Mr. Bishop: In regard to the question box I would say there are two kinds of question boxes, one for the purpose of discussion and one for the purpose of information. We have for a number of years maintained a question box, and up to three years ago the question box was sent to the members of the association a little prior to the annual meeting, and their answers were incorporated in printed form and distributed among the members at the meeting. We found that to be a disadvantage. If a man asked a question for information he did not want it to wait for eleven months possibly for an answer, or two months. It might be something that he wants to know within two weeks. So they have abandoned the question box, and as the questions are asked they are distributed to the membership, and then the person who asks the question is immediately informed on the subject. At the end of the year these questions and their answers are incorporated in the question box of the association. That is a great way of helping all the members of the association. The purpose of this question box is for discussion only, and I do not think we need it. If it is for a matter of information, we certainly do not want to wait until the end of the year to get an answer.

Secretary Mackay: It would take possibly sixty days from the time the Secretary received the questions before they could be distributed among the members and get returns. An answer should not be expected within sixty days or longer.

Mr. Chew's motion was agreed to.

Topic No. 13, The deposit of lime or other mineral from impregnated water in a heated pipe with relation to diameter or area or the relative deposit in a one and two-in. pipe in a given time, was presented, but there was no discussion.

Topic No. 14, A standard schedule of blast area and lineal feet of one-inch pipe in air-heating stacks and coils based on the cubic feet of air passed through the heater per hour or minute, and the mean difference between inside and outside temperature at velocities from 1,000 to 1,800 feet per minute was discussed by Mr. Barwick.

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President Mackay: The committee of which I have been chairman have Nos. 14 and 15 covered in a general way in the questions sent out, so that that matter is really being taken care of.

Topic No. 15, The factor to be taken into consideration and the proper method of rating fan heating coils in determining the coefficient of heat transmission under different conditions of temperature, was not discussed.

Topic No. 16, The standard rules of the Society for efficiency and value of the heating surface of different types of direct, direct-indirect, indirect and forced blast radiation, was briefly discussed by Mr. Barwick.

The meeting then adjourned.

List of members and guests present at Fifteenth Annual Meeting, January 19-20-21, 1909.

MEMBERS:

ADDAMS, HOMER
ALLEN, JOHN K.
ANDRUS, N. P.
ARMAGNAC, A. S.
AUSTIN, W. E.
BADGER, O. L.
BARR, GEO. W.
BARWICK, THOS.
BERMAN, LOUIS K.
BISHOP, C. R.
BIRDSALL, W. A.
BLACKMORE, J. J.
BOYDEN, D. S.
BRADLEY, J. T.
BRENNAN, JOHN S.
CARPENTER, R. C.
CHEW, FRANK K.
CLARK, WM. D.
CLARK, GEO. W.
COLLINS, L. D.
CRANE, H. D.
CRIPPS, A. G.
CRYER, A. A.
CRYER, T. B.
DAVIS, B. C.
DICK, THOS.
DONNELLY, JAS. A.
DORNHEIM, G. A.
DRISCOLL, W. H.
DWYER, F. A.
EDGAR, A. C.
ENGLAND, GEO. B.
FARNHAM, GEO. D.
FELDMAN, A. M.
GIFFORD, R. L.
GOMBERS, HENRY B.
GRAHAM, JOS.
GREEY, C. V.
GREENMAN, GEO. L.
HALE, JOHN F.
HANKIN, RICHARD
HARVEY, ANDREW
HOFFMAN, GEO. D.
JOSLIN, HERBERT A.
KEHM, AUG.
KENNEDY, CHAS. B.
KIEWITZ, CONWAY
KIMBALL, D. D.
KINEALY, J. H.
KNIGHT, GEO. W.
LEWIS, S. R.
MACKAY, JAMES
MACKAY, W. M.
MACON, W. W.
MCCANN, FRANK G.
MCKIEVER, W. H.
MOFFETT, W. S.
MONASH, M. E.
MORRISON, CHAS.
MUNROE, E. K.
MYRICK, J. W. H.
OLDACRE, C. E.
O'HANLON, GEO.
OSBOURN, M. P.
PARTER, S. C.
PAUL, ANDREW G.
RICE, DANIEL J.
RITCHIE, WM.
SEWARD, P. C.
SCOLLAY, U. G.
SCHAFFER, JOHN P.
SHANKLIN, JOHN R.
SHERMAN, L. B.
SNOW, WM. G.

STANGLAND, B. F.
STEVENS, FRANK H.
SNYDER, C. B. J.
TERAN, CESAR
THOMAS, M. F.
THOMSON, T. N.
VROOMAN, W. C.
WEBSTER, WARREN
WEINSHANK, THEO.
WHITTEN, H. W.
WILSON, H. A.

GUESTS:

BARNES, E. W.
BEADLE, S. A.
BLACK, JOHN
BRAEMER, W. G. R.
BRODNAX, C. M.
BULETTE, L. D.
BUSHNELL, H. C.
CARNEY, JOHN F.
CATILLAZ, C. T.
COMMER, F. M.
CRAWFORD, E. F.
DAVIES, R. A.
DEAN, MARK
DELORME, J. F.
DOBBS, J. E.
ENSIGN, D. M.
FAULKNER, J. C.
FISHER, E. H.
FISK, E. C.
FUNDINGER, C. G.
GARFIELD, J. B.
GLESSNER, A. W.
GORTON, C. E.
GRIMSHAW, G. E.
GULLZERS, C. W.
HAENSEL, C. W.
HALL, A. EDSON
HALL, B. P.
HARWOOD, G. A.
HEG, JAS. E.
HOLBROOK, J. B.
HUNT, R. B.
KEASBEY, R. A.
KENNEY, H. E.
KITCHEN, J. M. W.
LECOMPTE, W. G.
LORENTZEN, CARL
MAYO, ROBT., JR.
MACFARLAN, J. P.
MARKS, H. J.
MCKEAN, J. F.
MCKNIGHT, C. P.
MILLER, CHAS. A.
MORGAN, W. W., JR.
MOSNER, JOHN
MOORE, LEW
NICHOLS, E. M.
OLD, C. W.
O'NEILL, A. J.
PRICE, M. D.
PRYOR, R. W., JR.
QUAY, C. S.
RICHARDS, P. M.
RITTER, ARTHUR
SCHWINDT, A. G.
SEYMOUR, C. H.
SISSON, C. W.
SPRAGGE, E. E.
SORG, E. L.
SNOWMAN, A. E.
SHANNON, W. R.
STERN, DANIEL
STEWART, D.
STORM, E. S.
THOMAS, L.
THOMASON, L. S.
TUCKMAN, S. E.
WEBSTER, A. S.
WEST, PERRY
WHEATLEY, THOS.
WINANS, M. E.
WINSLOW, E. D. F.
WYLIE, H. M.
ZELLERS, G. H.

PAPERS

OF THE

FIFTEENTH ANNUAL MEETING,

New York, January 19–21, 1909.

CXCVI.

THE TESTING AND RATING OF HOUSE-HEATING BOILERS.

BY WILLIAM KENT.

(Member of the Society.)

Testing Cast-iron House-heating Boilers.

The testing of the evaporating power and the economy of small-sized boilers is more difficult than the testing of large steam-boilers for the reason that the small quantity of coal burned in a day makes it impossible to procure a uniform condition of the coal on the grate throughout the test, and large errors are apt to be made in the calculation on account of the difference of condition at the beginning and end of a test. The following is suggested as a method of test which will avoid these errors.

(*a*) Measure the grate-surface and weigh out an amount of coal equal to 30, 40, or 50 pounds per square foot of grate, according to the type A, B, or C, or the ratio of heating- to grate-surface.

(*b*) Disconnect the steam-pipe, so that the steam may be wasted at atmospheric pressure. Fill the boiler with cold water to a marked level, and take the weight of this water and its temperature.

(*c*) Start a brisk fire with plenty of wood, so as to cause the coal to ignite rapidly; feed the coal as needed, and gradually increase the thickness of the bed of coal as it burns brightly on top, getting the fire-pot full as the last of the coal is fired. Then burn away all the coal until it ceases to make steam, when the test may be considered as at an end.

(*d*) Record the temperature of the gases of combustion in the flue every half-hour.

(*e*) Periodically, as needed, feed cold water, which has been weighed, to bring the water level to the original mark. Record the time and the weight.

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CALCULATIONS.

Total water fed to the boiler, including original cold water, pounds × (212°−original cold-water temperature)=..... B.T.U.
Water apparently evaporated, pounds × 970=..... B.T.U.
Add correction for increased bulk of hot water:
Original water, pounds × $\frac{(62.3-59.8)}{62.3}$ × 970=..... B.T.U.
Total..... B.T.U.

Divide by 970 to obtain equivalent water evaporation from and at 212 degrees F.

Divide by the number of pounds of coal plus pounds of wood by 0.4 to obtain equivalent water per pound of coal.

The last result may be considerably less than 10 pounds on account of imperfect combustion at the beginning of the test, excessive air-supply, when the coal bed is thin in the latter half of the test, and loss by radiation, but the results will be fairly comparable with other results from boilers of the same size and run under the same conditions. The records of water fed and of temperature of gases should be plotted, with time as the base, for comparison with other tests.

RATING HOUSE-HEATING CAST-IRON STEAM-BOILERS.

The rating of a steam-boiler for house-heating may be based upon one or more of several data: 1, square feet of grate-surface; 2, square feet of heating-surface; 3, coal-burning capacity; 4, steam-making capacity; 5, square feet of steam-radiating-surface, including mains, that it will supply. In establishing such a rating the following considerations should be taken into account:

1. One square foot of cast-iron radiator surface will give off about 250 B.T.U. per hour under ordinary conditions of temperature of steam at 212 degrees and temperature of room at 70 degrees.

2. One pound of good anthracite or semi-bituminous coal under the best conditions of air-supply, in a boiler properly proportioned, will transmit about 10,000 B. T. U. to the boiler.

3. In order to obtain this economical result from the coal the boilers should be driven at a rate not greatly exceeding 2 pounds of water evaporated from and at 212 degrees per square foot of heating-surface per hour, corresponding to a heat transmission of $2 \times 970 = 1{,}940$, or, say, approximately 2,000 B. T. U. per hour per square foot of heating-surface.

4. A satisfactory boiler or furnace for house-heating should

not require coal to be fed oftener than once in 8 hours; this requires a rate of burning of only 3 to 5 pounds of coal per square foot of grate per hour.

5. For commercial and constructive reasons, it is not convenient to establish a fixed ratio of heating- to grate-surface for all sizes of boilers. The grate-surface is limited by the available area in which it may be placed, but on a given grate more heating-surface may be piled in one form of boiler than in another, and in boilers of one general form one boiler may be built higher than another, obtaining thus a greater amount of heating-surface.

6. The rate of burning coal and the ratio of heating- to grate-surface both being variable, the coal-burning rate and the ratio may be so related to each other as to establish condition 3, viz., a rate of evaporation of 2 pounds of water from and at 212 degrees per square foot of heating-surface per hour.

These general considerations lead to the following calculations:

1 lb. of coal, 10,000 B.T.U. utilized in the boiler, will supply 10,000÷250=40 sq. ft. radiating-surface.
1 lb. of coal, 10,000 B.T.U. utilized in the boiler, will require 10,000÷2,000=5 sq. ft. heating-surface.
1 sq. ft. of boiler heating-surface will supply 2,000÷250 or 40÷5=8 sq. ft. radiating-surface.

	Low boiler.	Medium.	High boiler.
1 sq. ft. of grate-surface should burn.....	3	4	5 lb. coal per hour.
1 sq. ft. of grate-surface should develop....	30,000	40,000	50,000 B.T.U. per hour.
1 sq. ft. of grate-surface will require.....	15	20	25 sq. ft. heating-surface.
1 sq. ft. of grate-surface will supply.....	120	160	200 sq. ft. radiating-surface.
Type of boiler, depending on ratio heating-surface÷grate surface.....	A.	B.	C.

TABLE OF RATINGS.

Type and No.	Square Feet Grate.	Square Feet Heating-surface.	Coal Burned per Hour. Pounds.	Water Evaporated per Hour. Pounds.	Radiating-surface Supplied. Square Feet.
A 1.....	1	15	3	30	120
A 2.....	2	30	6	60	240
A 3.....	3	45	9	90	360
A 4.....	4	60	12	120	480
A 5.....	5	75	15	150	600
B 4.....	4	80	16	160	640
B 5.....	5	100	20	200	800
B 6.....	6	120	24	240	960
B 7.....	7	140	28	280	1,120
B 8.....	8	160	32	320	1,280
C 6.....	6	150	30	300	1,200
C 7.....	7	175	35	350	1,400
C 8.....	8	200	40	400	1,600
C 10.....	10	250	50	500	2,000
C 12.....	12	300	60	600	2,400
C 14.....	14	350	70	700	2,800
C 16.....	16	400	80	800	3,200

The table is based on the utilization in the boiler of 10,000 B.T.U. per pound of good coal. For poorer coal the same figures will hold good except the pounds coal burned per hour, which should be increased in the ratio of the B.T.U. of the good to that of the poor coal. Thus for coal from which 8,000 B.T.U. can be utilized the coal burned per hour will be 25 per cent. greater.

For comparison with the above table the following figures are taken and calculated from the catalogue of a prominent maker of cast-iron boilers:

Height.	G Grate.	H Heating-surface.	R Radiating-surface.	$\frac{H}{G}$	$\frac{R}{G}$	$\frac{R}{H}$	B.T.U. per Hour =R × 250	$\frac{B.T.U.}{H}$	Coal per hour per sq. ft. grate. *
Low	2.1	45	210	21.5	100	4.7	52,500	1,167	2.5
	4.7	90	600	19.1	128	6.7	150,000	1,667	3.2
Medium	4.2	103	600	24.5	143	5.8	150,000	1,456	3.6
	8.2	195	1,500	23.8	183	7.7	375,000	1,923	4.6
High	6.7	210	1,200	31.3	179	5.7	300,000	1,476	4.5
	14.7	420	3,300	28.6	225	7.9	825,000	1,964	5.6

* Equals B.T.U. per hour÷10,000 G.

CXCVII.

A STANDARD RATING FOR STEAM AND HOT WATER HEATING BOILERS.

BY PERCIVAL H. SEWARD.

(Member of the Society.)

The records of this Society contain more reference to the question of ratings for heating boilers than to any other single problem, and a perusal of the same as well as the articles and discussion in trade papers indicates a general desire for some method which will make a standard rating possible and convenient for all parties interested.

Three committees have been appointed by this Society whose duties embrace the subject of heating boiler ratings, but no conclusions have been reached because attention has been diverted from uniform rating to uniform construction.

It is clearly not within the scope of the Society to set a standard for uniform construction and efforts along that line will always result in failure and discredit.

A uniform construction would not be desirable, and no standard can ever be adopted which even suggests construction without leading to freak boilers and complete paralysis of effort for future improvements.

At the last annual meeting of this Society the committee appointed to secure data on hot water heating submitted their report with the following statement in regard to boilers.

"Many boilers for residence heating are not rated satisfactorily in the catalogue. Among twelve familiar types the hot water rating for the same grate surface varies from 2,800 to 3,875 square feet. The amount of heating surface is not generally published, and information is difficult to obtain. It probably varies 50 per cent. among these same twelve types."

The discussion which followed the reading of this report was

with reference to the value of heating surface, and the quantity of the same that should be used in a boiler instead of the method for obtaining uniform ratings, which are desired.

A belief is becoming general that the rating of all heating boilers can never be made uniform by any calculations based on quantity and quality of their surfaces, because of the very numerous forms in which these surfaces can be cast and placed.

The only consideration is efficiency, as determined by test of each individual boiler or design, and it is the opinion of many engineers that this Society should set a standard for such a test with a formula for determining the power or rated capacity of the boiler.

While it is possible that experiments and tests, the results of which are at this time available, may give some data from which conclusions can be drawn as to the value of heating surfaces in certain types of cast iron boilers, investigations along purely commercial lines lead to the conclusion that the makers of such boilers determine the value of the heating surface by test of boiler as a whole, and make no attempt to determine the ratio of work done in the fire box or flues.

There is a general desire for knowledge on this matter of distributing the work done, but the experiments necessary are expensive and complicated, and so far as can be learned nothing has been attempted except in a very crude way with some makes of boilers, which readily admit a separation and division of parts to follow the two generally accepted types of heating surface—direct and flue.

A study of many patterns of cast iron heating boilers indicates the almost impossible task of attempting to determine by any general and easily applied rule or formula the evaporative power of their various heating surfaces.

There is a widespread and growing conviction among manufacturers of these boilers to the effect that each individual construction must be tested to determine its heating power as expressed by evaporation of water.

The reason for this is evident when it is noted that with very few exceptions a cast iron heating boiler changes its proportions with every size, therefore, to test one size and measure the others will lead to some almost ludicrous conclusions as to capacity.

The varying length of flue travel is one of the features that might be called to mind in explaining the difficulty referred to, especially when we take into consideration the theoretical value of surface as calculated by difference in temperature between the gases and the water. Furthermore calculations which can be made by temperatures somewhat easily obtained are subject to very great modification by the rapidity with which the gases travel, the angle at which they impinge and movement of water on the inside of the surface.

These considerations vary with each type of boiler, and in many cases with each size of given type, and they are furthermore complicated by changes in the facility for cleaning, which sometimes reach the extreme of making that operation almost impossible on certain sizes.

Other varying factors, even though tests were commercially possible to determine the value of surface, would be the efficiency to be obtained from fuel, the rapidity which coal can or will be burned, and the length of time the fire should maintain the maximum requirement without attention.

The conclusion is that no data on the relative value of heating surfaces in cast iron boilers exist or can very easily be obtained at a cost commensurate with the results desired, therefore, the capacity of heating boilers should be determined by tests made under certain well-defined standard conditions.

The power of a cast iron boiler when used for the purpose of heating residences and other buildings is usually expressed in square feet of cast iron radiators or radiation that it will supply.

This method of expressing the power of such boilers has in all probability been acceptable to the steamfitting trade and to heating engineers, because the load or work to be done was usually calculated or reduced to the same terms.

Of late years there has been noticed a general agitation in favor of the heat unit for a conclusion as well as a basis in heat calculations. Such agitation has resulted in a general extension of knowledge and a very wide familiarity with the British thermal unit and the accuracy as well as convenience attending its use.

A student of heat engineering as well as of ventilation is compelled to recognize and understand the heat unit at the very commencement of his studies and, therefore, drops it with re-

luctance on concluding his educational course and entering general practice.

All text-books and even papers and essays on heating and ventilation now refer to and use the heat unit—not as something mystifying or carrying an air of confusion—but as a necessity to any reasonably brief and conclusive argument, illustration or formula.

In consequence of all this the British thermal unit is so well understood and correspondingly desired that there appears to be no longer any adequate reason or even argument why it should not be adopted as the expression of power in boilers used exclusively for heating purposes.

For immediate convenience it would be advisable to express the power in heat units and also in square feet of direct radiation, with note or explanation of the rule used in making the conversion from one to the other. This ratio of conversion will have to be arbitrarily set, because "square feet of direct radiation" means nothing definite and is nothing definite.

A review of the expressed opinions and observations of many members of this Society and other authorities will show that so far as this term means anything at all, it represents 250 B. T. U. when used for heating with steam up to three pounds gauge pressure, or 150 B. T. U. when used for heating with water at 165 degrees average temperature, the surrounding air being calculated at 70 degrees Fahr. It would seem that the power of heating boilers expressed in B. T. U. and followed by an equivalent in square feet of direct radiation at rate of 250 for steam and 150 for water would cover all requirements, as well as objections for the present, and would ultimately lead to the use of heat units exclusively.

It is very certain that the competent engineer or steamfitter with a boiler under consideration whose power is expressed in B. T. U. will be able to make all his calculations in terms to correspond, and in that way insure to a certain extent more accurate proportions and in consequence greater credit to himself and to the business at large.

Concluding that the use of B. T. U. for expressing the power of heating boilers is desirable, we must know for what length of time the capacity is available, calculating, of course, for a full charge of coal in fire box of the boiler.

A boiler's full power or potential is expressed correctly by the B. T. U. available on a run which consumes 80 per cent. of the entire charge of coal. This time may be one or twelve hours, or even more in extreme cases. The rating, however, is made on an hourly basis, and the engineer must know on what length of run it is calculated before he can use the boiler for a given set of conditions.

The opinions as to the time for length of run are fairly uniform and, as expressed before this Society or in publications of recognized merit, seem to be in favor of a minimum run of eight hours for those sizes of boilers used to heat ordinary dwelling houses, with an inclination to a shortening of the time as the size of boiler increases.

This reasoning appears logical when we consider a business day is of eight hours, and an ordinary house heater might expect attention at about the time such a day commences and ends. The night factor also fits in very nicely, because the majority of householders desire very little heat during hours of sleep, and as a matter of common observation generally check the fire. Should full heat be needed at night for sickness or other reason, the eight hour period just naturally divides the day into three equal parts and provides convenient intervals to give attention to the fire.

For boilers and heaters used in larger residences and in small schools or hotels an eight hour run is not so essential, and in all probability a period of seven hours would find no criticism among the users of such apparatus.

The consideration of large boilers requires a six-hour run for economy of installation, ease of operation, convenience of attendant and general adaptation to the requirements of buildings in which they would likely be installed.

The defining of the size of boiler, which shall be operated in the three foregoing divisions of time is best determined by size of grate as follows:

Small boilers, less than 6 square feet grate, 8 hours run.
Medium boilers, 6 to 10 square feet grate, 7 hours run.
Large boilers, over 10 square feet grate, 6 hours run.

The engineer selecting a heating boiler for which a time factor has been provided would naturally consider his particu-

lar installation to decide if the boiler he was about to select would develop the power at which it was rated under the conditions to which he was limited.

No conclusion can be reached under this line of reasoning without a knowledge of the conditions which govern the test of a boiler to determine its rating, and an intelligent comparison of such conditions with those for the installation under consideration.

The unknown quantity in present published ratings of heating boilers is coal consumption, and this must be made standard before the engineer can judge as to the likelihood of his conditions making the same consumption possible with similar results as expressed in the boiler's B. T. U. capacity. A fairly wide difference of opinion is expressed on this point of coal consumption, but such opinions are quite uniform as to advisability of distinction between heating boilers with the usual expectation of careless and sometimes most ignorant attendants, and those boilers made for and used in power work where more or less skilled firemen are employed.

Another feature, in fact, the feature, which runs hand in hand with inefficient help, is a limit of chimney power for house heating boilers.

It is undoubtedly true that a chimney of adequate draft must be provided for each installation; but it, nevertheless, remains obvious that such chimney requirements must be within reason and applicable to the design and construction of the class of buildings in which the boilers under consideration are usually installed.

Leaving out of consideration the special case—be it good or bad—which a competent engineer can always calculate for, the records of this Society and publications of recognized merit point clearly to a moderate rate of combustion as likely to meet general approval in heating practice, and provide greatest economy under average conditions.

Keeping in mind again the ability of an engineer to suit his calculations to special requirements, the following basis of coal consumption seems obvious:

Small boilers, less than 6 sq. ft. grate, 5 lbs. coal per square foot grate per hour.

Medium boilers, 6 to 10 sq. ft. grate, 5 to 6 lbs. coal per square foot grate per hour.

Large boilers, over 10 sq. ft. grate, 6 to 7 lbs coal per square foot grate per hour.

This question is largely influenced by the handling of the coal as well as the ability of chimney to furnish draft. Considering the time factor as previously alluded to and the quantity of coal as just expressed in pounds per hour for each square foot of grate we arrive at a total consumption of about 40 pounds for each square foot of grate for one firing. This is the amount of coal to be actually consumed; therefore we must add to it sufficient for a bed on which to ignite the new charge, such surplus usually being estimated as one-fourth of the amount to be consumed, or in this case ten pounds, making a total charge of 50 pounds for each square foot of grate. This charge of 50 pounds has to be handled each eight, seven or six hours, as the case may be, and looks quite a substantial amount when we consider that it figures up to 250 pounds or one-eighth of a ton, as required for one charge on a boiler of five square feet grate area, such as would be suitable for the ordinary residence.

Coming back again to the draft, the charge of 50 pounds for each square foot of grate provides a fuel bed, which will average about 15 inches deep, 12 inches of which will be the new charge of fuel and 3 inches the old bed, which remains practically constant. Through this mass of fuel the chimney must exert itself to maintain active combustion, and experience with many hundreds of heating plants indicates 15 inches in depth of fuel as a maximum, and makes it unsafe to expect average results if it is increased.

Accepting the full charge as 50 pounds, of which 40 pounds is available for combustion, we find it regulates our coal burning factor as follows:

Small boilers, less than 6 sq. ft. grate, 5 lbs. coal per sq. ft. grate per hour.

Medium boilers, 6 to 10 sq. ft. grate, 5.7 lbs. coal per sq. ft. grate per hour.

Large boilers, over 10 sq. ft. grate, 6.6 lbs. coal per sq. ft. grate per hour.

With the time factor set and the rate of combustion decided upon the engineer now has to consider only the factor of efficiency to enable him to determine his own rating for any given boiler under any specified conditions, according to the following formula:

Small boilers, G x 5 x E = B. T. U. per hour for 8 hour run.

Medium boilers, G x 6.6 x E = B. T. U. per hour for 7 hour run.

Large boilers, G x 6.6 x E = B. T. U. per hour for 6 hour run.

G is area of grate in square feet.

E is efficiency in B. T. U. per pound of coal.

For direct radiation divide B. T. U. by 250 for steam.

For direct radiation divide B. T. U. by 150 for water.

The factor E should be supplied by maker of the boiler; but if not available it can be determined by the engineer from any published rating, providing the area of grate is known and the coal consumption is accepted in accordance with the foregoing conclusions.

The formula for determining value of E from any given rating is as follows:

$$\frac{\text{B. T. U.}}{\text{G x C}} = \text{E.}$$

G is area of grate in square feet.

C is coal in pounds per hour for each square foot grate.

E is efficiency in B. T. U. per pound of coal.

For convenience in illustrating the practical ability of this method of rating boilers the following schedule has been prepared to show the rating for heating boilers at varied efficiency, dividing them into three classes, small, medium and large, and covering the range of efficiency, which might be expected.

Any rating for efficiency other than shown in the table can easily be figured by working back to the heat units available for each square inch of grate, and taking such percentage of it as the test of the boiler shows can be expected.

SCHEDULE OF HEATING BOILER RATINGS.

Figured for One Square Inch of Grate Area.

Rate of Combustion, Pounds of Coal Per Square Foot Grate Per Hour.		Small Boilers. 5	Medium Boilers. 5.7	Large Boilers. 6.6	Total B.T.U. from 1 lb. Coal.
100% efficiency	B. T. U.	500	570	660	14400
		——Ratings per sq. in. of grate——			
40% efficiency	B. T. U.	200	228	264	5760
40% "	Steam, sq. ft.	0.80	0.91	1.06	"
40% "	Water, sq. ft.	1.33	1.52	1.76	"
45% "	B. T. U.	225	257	297	6480
45% "	Steam, sq. ft.	0.90	1.03	1.19	"
45% "	Water, sq. ft.	1.50	1.71	1.98	"
50% "	B. T. U.	250	285	330	7200
50% "	Steam, sq. ft.	1.00	1.14	1.32	"
50% "	Water, sq. ft.	1.67	1.90	2.20	"
55% "	B. T. U.	275	314	363	7920
55% "	Steam, sq. ft.	1.10	1.26	1.45	"
55% "	Water, sq. ft.	1.83	2.09	2.42	"
60% "	B. T. U.	300	342	396	8640
60% "	Steam, sq. ft.	1.20	1.37	1.58	"
60% "	Water, sq. ft.	2.00	2.28	2.64	"
65% "	B. T. U.	325	371	429	9360
65% "	Steam, sq. ft.	1.30	1.48	1.72	"
65% "	Water, sq. ft.	2.17	2.47	2.86	"
70% "	B. T. U.	350	399	462	10800
70% "	Steam, sq. ft.	1.40	1.60	1.85	"
70% "	Water, sq. ft.	2.33	2.66	3.08	"

Small Boilers, less than 6 sq. ft. grate area.
Medium Boilers, 6 to 10 sq. ft. grate area.
Large Boilers, over 10 sq. ft. grate area.

Coal charge 50 pounds per sq. ft. of grate, of which 80% or 40 pounds is to be consumed in 8 hours for small, 7 hours for medium, and 6 hours for large boilers. The theoretical value of coal is placed at 14400 B. T. U. per pound, for convenience in calculations, on basis of 100 B. T. U. per square inch of grate for each pound of coal.

The percentage of efficiency should be adjusted for actual value of the coal used in the test, but the rating remains constant for the B. T. U. available per pound of coal as stated in the last column.

Steam radiation is figured 250 B. T. U. per hour.

Water radiation is figured 150 B. T. U. per hour.

The rating is for one hour, but is available for each hour of the entire run on one charge of coal as indicated.

The rating is available at the boiler outlet, the load to be calculated from that point.

The manufacturer who uses this standard rating should state and guarantee the efficiency under which he makes his calculations, such efficiency being reduced to the basis of 14,400 B. T. U. per pound of coal, the rate of combustion not to exceed the rate specified.

The engineer installing the boiler must suit it to the conditions at hand, no guarantee excepting for tested efficiency being required of the maker. The test should be standard and uniform in all cases, and subject to the approval of a special committee of three engineers appointed by this Society expressly for that purpose, who would on request of a boiler manufacturer witness such test as he might desire to make and certify to its correctness, and also to the correctness of the calculated efficiency for other sizes of the same proportions.

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The maker of a boiler should not expect this committee to be present at the preliminary tests, but only at the final tests when the efficiency of the boiler has been decided upon, and a certificate was desired to the effect that the boiler actually developed such efficiency by standard test in the presence of the majority of the members of the committee.

The expenses of the committee should be paid by the maker of the boiler, allowing only for transportation and hotel charges.

With a standard rating guaranteed under a uniform test the manufacturer will be free to develop a boiler of the highest efficiency, and the engineer who designs the installation will be solely responsible for correctly applying the boiler to the local conditions which are available.

President Mackay: We have with us Mr. Nichols, of the Master Steamfitters Association, who is Chairman of their Standardization Committee.

Mr. Nichols: Mr. President and gentlemen of the Society: I am here as one of the committee representing the Master Hot Water and Steamfitters on the subject of standard sizes of hot water heating boilers. At our last annual convention, when the matter was brought up, I made the remark that there was only one way to rate a boiler, and that was to test it. I do not know any other way of figuring it out other than by actual test. I am free to say that I cannot add anything to what Mr. Seward has said here to-night. I represent a body of men on whom the burden naturally falls if there is anything wrong, and I fully agree with him that a standard of efficiency is what must be determined in each boiler. I have in mind the idea that we should test every boiler that is catalogued, or there should be some test made and certified to by a body, I do not know whether the manufacturers or the National Association of Steam and Hot Water Fitters. The Association will be glad to coöperate with this Society and make suggestions under which a boiler should be tested or in any other way they can to aid the matter. We are certain that the ratings which are given to us by the different manufacturers are confusing, and we know to our sorrow they are sometimes wrong. We realize, however, that the amount of work that a boiler can do is determined somewhat by the efficiency. Those are the conditions with which the boiler maker has nothing to do whatever, the consumption of

fuel and efficiency of that fuel. The heating of water either into steam or hot water are the only factors that we need consider at all. Outside of that, of course, is the matter of the amount of work it will perform under certain conditions. That is outside of the efficiency of the boiler entirely, and it is a matter that must be determined largely by experience, and our committee came here to-day to listen to what you people have to say. We stand ready to coöperate with you.

Mr. Snow: There is one point in regard to this table on which I am not at all clear, and that is the basis on which this table rests, in which it states that the total B. T. U. for one pound of coal is 100 per cent. efficiency or 14,400. I wish to inquire whether that is coal or combustible.

Mr. Nichols: That would probably be combustible. The point is that if the efficiency is figured out on one basis, and that basis is recognized it does not make much difference what the basis is. It is generally understood that the value of coal is around 14,400 per pound of combustible. Take 90 or 100 men out of this room and ask them what they value it, and they will state 14,400 B. T. U. per pound. It has been published in text-books so long, and it has become so generally recognized by using the term coal instead of combustible that most people accept it that way.

Mr. Seward: If 14,400 B. T. U. per pound of coal is accepted as the basis and the boiler is rated at 70 per cent. efficiency by the manufacturer, and advertised as such, it makes a very simple calculation to determine the capacity. So long as we are going to set an arbitrary theoretical value for coal we might as well make it 100 B. T. U. per square inch of grate for each pound of coal burned per square foot, and save a great deal of trouble in making calculations. The test committee that might be appointed by this Society to supervise tests would naturally go into the analysis of the coal used and percentage of efficiency that the manufacturer claimed for his boiler with such coal and then adjust the efficiency on the basis of a theoretical value of 14,400 B. T. U. per pound. This arrangement does not hurt any manufacturer, because so long as the basis is the same for every test it is as fair to one as to another. That is my only explanation for using the arbitrary figures of 14,400 as the theoretical B. T. U. per pound of anthracite coal.

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Mr. Snow: That answers my question. It means that you must have one pound of combustible to get 14,400 heat units.

Mr. Seward: That is very true. It means that if the manufacturer has made a boiler that develops 9,000 heat units per pound of ordinary anthracite coal, this test committee will certify to that as equivalent to a little less than 62 per cent. on the 14,400 basis, and so long as everybody uses the same basis it does not make any difference what the real value of the coal is. I would like to call attention to the fact that this discussion of ratings has extended clear across the ocean, and is being taken up before the British Society of Heating and Ventilating Engineers. On June 22, 1908, Walter Jones, who, I believe, is also a member of our Society, read a paper before the British Institute of Heating and Ventilating Engineers on this subject of uniform boiler ratings, with a long preamble and discussion of boiler construction, after which he gave a lot of facts and figures as to how to construct the theoretical boiler. At the end of his paper, however, he states, "another and probably better suggestion is to abandon the method of rating by boiler surface altogether, and instead ascertain the heating power in heat units by carefully testing how many pounds of water could be evaporated into steam per hour with a specified consumption of coal."

Now, I am pretty sure if we here do not set a standard method for computing boiler ratings we will either get a German standard or a British standard. The boilers that are sold in the German market are freak boilers. There are some of them made here but rarely sold. We do not want the German method or an English method. Let us go ahead and set the standard to suit our own conditions. We have been discussing it long enough. There are sufficient people in the business and enough money in the business to warrant attention; therefore, I think if this Society is going to do anything of credit and with prestige to itself it ought to settle this question by deciding what is the coal consumption to be expected under normal conditions in heating boilers.

Mr. Macon: Isn't there likely to be considerable opposition to such a scheme as outlined on the part of the manufacturers?

Mr. Seward: I cannot answer for the manufacturers. I am simply giving you my ideas as a member of this Society, not as a boiler manufacturer. What the manufacturer would do I can-

not say. The general assumption is that when you put any common sense proposition before a man he will ultimately see it. This proposed standard rating is a common sense proposition. If it is not we had better let it alone.

Mr. Nichols: I believe the majority of purchasers of boilers will patronize a man who is willing to have the efficiency of his boiler certified to by a disinterested party. In other words, I would be more willing to take the certificate of a disinterested party than I would of the man who was interested himself in that boiler, and for that reason I am inclined to think that each manufacturer would undoubtedly put forth his best efforts in this direction. I am certain if we put the proposition up to them there is not a boiler manufacturer who would not be glad to have the boiler certified to.

Mr. Seward: There is not a boiler made in this country but will carry its rating under certain conditions. I think when you question the present ratings of boilers you should qualify it by stating that such ratings are undoubtedly right for some conditions. What the manufacturer needs is to know the normal conditions of operation.

Mr. Weinshank: I am glad this discussion has come up this evening, for the reason that one of the tests submitted in our report covered nearly every point raised this evening, and if we are successful before the next meeting we will have tests made at six or seven universities, and they will be given instructions to fill in the data that we have submitted this evening, and I hope we will get together by the next meeting and trust that if we do we will have pretty complete data on how to rate boilers.

Mr. Seward: I want to call Mr. Weinshank's attention to the fact that there are certain practical questions to be solved in connection with this proposed factor of the coal consumption that can be expected in domestic plants. There is no need of the steamfitter bothering his head about tests, as they interest the boiler maker only, showing him how he can get the most heating value in a cast iron boiler. They are valuable in that respect, but they do not throw any light on the question of average coal consumption that can be expected from domestic heating plants.

Professor Kinealy: The committee appointed by your Society to take up the question of rating cast iron boilers looked into the

subject and found some catalogues giving information as to how boilers are really rated. We thought we ought not to touch in our report nor in our recommendation upon anything that in any way hampered the manufacturers in designing and manufacturing their boilers. We thought that free range should be given to every designer and manufacturer in order that he might do his best, irrespective of what others were doing, and make a boiler that would be of benefit to the public. We, therefore, omitted from our work on standards the consideration of heating surfaces, because we found that there were so many different kinds of heating surfaces it would be impossible for us to enumerate them all and compare one with the other fairly. We knew of the direct fire surface, of the flue surface, of the horizontal flue surface, but how one compared with the other we had no method of knowing. We concluded that the rating of cast iron boilers could be made on something that all boilers must have, and after considerable discussion we concluded the only thing they had in common and more nearly alike was the grate, and so we concluded the area of the grate surface was the thing to base our standard upon. Of course that gave rise to the question how to measure the area of the grate surface. Should we measure directly at the level of the grate or at the top of the fire pot, and if at the level of the grate should we take into account any irregularities in the grate bars themselves. We concluded the area of the grate should be the horizontal area directly above the grate surface, omitting entirely the irregularities in the grate due to the type of grate bar. Taking that as a basis we saw our way clear to something else. The next thing was, how much heat should we expect from a boiler having a certain grate surface. For the purpose of making our ratings similar we assumed one pound of steam was equivalent to 1,000 B. T. U., and we thought that the combustion we could get from a small boiler would not be nearly as efficient as for a large one; because the small boiler, that is, one having a small grate surface, burned coal at a slower rate than the large one.

Next came up the question as to how big the fire pot ought to be, that is to say, how long a time should elapse between charging or firing of the furnace. We thought in the small furnace it should be greater than the large boiler, for the reason the small boilers would probably be taken care of by women,

whereas the large boilers would be taken care of by men; the very large ones, of course, being fired by some one whose duty would be to look after the boiler entirely. So with the grate surface we made a second column of standardization which we called the weight of the coal in the fire pot. That means the weight of the coal, without any fire, on the grate up level with the bottom of the fire doors.

Then came the question of testing whether it was or was not a standard boiler. You can all understand, if we should build a fresh fire in a boiler and run the boiler only for an hour or two, then test it, we might get one result; whereas if we run it for a long time we might get another. We thought that the fire should be built in the boiler and the boiler charged, and then the boiler run without any fresh charging for the time we have specified.

Summing up, the committee based its rating on the area of grate surface and the conditions of the draft with the boiler installed such that the boiler will burn the amount of coal per hour given in column marked "coal per hour." It is up to the user of the boiler to get his draft so the boiler will burn that amount of coal, then you have a standard boiler under standard conditions. Under these conditions, after a boiler has been charged, it must be run without any further charging of coal, without any further coal being put on—this length of time, and then the test of one hour must be run. And, during that hour the boiler must make this much steam. (Indicated on the blackboard.) That would be a standard boiler under standard conditions, and that standard boiler will carry the radiation given in the radiation column.

Professor Carpenter: It seems to me the report is practically along the right lines. Starting at the lower limit of coal consumption it agrees with my experience. I have found out from practical tests with the coal we get in the East that the small heating boilers used under ordinary conditions burn about four pounds of coal per square foot of grate per hour. I do not know what size of grate permits you to increase this amount, but it is quite obvious that as the grate increases in size more coal can be burned per square foot of grate per hour for the same draft conditions. I know in an upright boiler in the University we may burn possibly five pounds in some cases. I am speaking,

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of course, of anthracite coal, so that I believe if the heater is to be satisfactory for a residence, and if it is not designed to burn the anthracite coal of the East, it has got to be designed on the basis that it will burn about four pounds of coal per square foot of grate per hour.

Regarding the heat value of coal, the heat value of anthracite coal varies a good deal, depending on how much ash it carries. About 12,500 B. T. U. per pound is about as high as anthracite coal of eastern Pennsylvania will run commercially.

There is a great difference in the relation of heating to grate surface in a power boiler and a heating boiler. The heating boilers are made, as a rule, as far as I can find from measurements about eight or ten square feet of heating surface to one of grate. The power boilers for anthracite coal have to have about 40 for soft coal and 60 for hard coal in order to give satisfactory results. If we were to burn a large amount of coal per square foot of grate with a heating boiler with that small amount of heating surface we would get very low efficiency. I feel very strongly that the heating boiler ought to be rated to burn a small amount of coal per square foot of grate per hour.

Professor Kent from his investigations has come to the same conclusion—that the heating boiler should burn about four pounds of coal per square foot of grate per hour. I should say put it somewhere about five.

I feel that it is rather important that the Society should definitely adopt a standard for the grate surface of small heating boilers. I would recommend five pounds per square foot per hour. I find that different boiler makers use different methods. For instance, a catalogue of a prominent firm gives the ratio of grate surface to radiation such as to require over eight pounds of coal per square foot of grate per hour. No wonder that the men who sell that boiler always put in one that is two sizes larger than the catalogue recommends. I cannot see what benefit there is for any manufacturer to put out any impossible rating. It certainly confuses the engineer and I don't believe it does anybody any good. I think it would be a benefit to adopt some sensible standard that these boilers will be rated on.

Mr. Barwick: Perhaps Professor Kinealy can give us some light as to whether he has made any tests in reference to the draft power, as I think it would be well to net the standard

of that power. Even our standard for burning a certain amount of coal may be placed on record.

Professor Kinealy: We could not get any information. That is one of the things the committee was up against. It is easy enough to say how much coal ought to be burned if you specify the draft. Nobody seemed to know anything about the draft for house boilers.

Mr. Seward: It seems to me that these discussions are for the purpose of standardization of a method for rating existing commercial boilers, and not for standardizing the construction of a theoretical boiler.

There are only two factors that you can take into consideration in connection with the rating of a boiler. One is the coal which it burns and the other is its efficiency. The coal consumption could be based on a certain number of pounds per square foot of grate per hour for a given length of time on one charge, as may be determined upon. The matter of efficiency is something that the manufacturer is solely responsible for, and, therefore, he should be allowed to make his boiler in any way that his commercial judgment dictates. Furthermore, I believe that we should take into consideration the fact that boilers are made to-day in all manner of shapes and sizes, and with all kinds of heating surfaces, and what is needed is a method of rating that will apply to those boilers as well as to the boilers of the future, which will be made as high as possible in efficiency, figured by the standard we adopt. I think the proper party to determine the question of coal consumption is this Society. It is composed of engineers and contractors, who have actual experience in such matters, and it ought to be within their power and discretion to determine what would be a normal expectation in regard to coal consumption in heating boilers of given grate area. If they will state that to the manufacturer he can then rate his present boiler by determining its efficiency, or he can build another boiler to develop a higher efficiency under the conditions which this Society lays down as to the coal consumption and time to run on one firing.

Every time this question comes up there is a general criticism of existent ratings. I think it is unfair. We have been criticising the manufacturers' ratings ever since this Society

was organized, yet we have never laid down any standard on which they should be based. Every manufacturer to-day rates his boiler on a standard, which is acceptable to himself, and which in his best judgment he believes to be right. If he is wrong it is for this Society or some other authority to show him. I do not believe it is fair to come here and criticize existing ratings, and not suggest a standard condition on which they could be based. I should like to see this matter disposed of, and I think a great many others would. It seems to me that if this Society can determine the normal rate of coal consumption in certain and definite sizes of boilers going by the area of the grate, and then say to the manufacturer, test your boiler on this basis to determine its efficiency, you will have solved the problem. We want to leave out of consideration altogether the theoretical question of what is the best method of construction.

Secretary Mackay: There is a feeling on the part of some manufacturers, steam fitters and others, that the present rating of house heating boilers is not constant, but varies in the same construction, same grate area, same application of surfaces, fire and flue. I understand the manufacturers of heating boilers have appointed a committee on rating, indicating they are not satisfied with their rating. Power boiler manufacturers have appointed a committee on rating of power boilers, and they have requested that we as a Society, or our committee on boiler rating, act with them. I do not think there is any thought or desire on the part of this Society to stir up the manufacturers or others, and tell them that they are wrong and that we are right, and that we know it all. They are coming to us and asking us to give our definition of what a proper rating for house heating boilers should be. I don't like it to go out that we are a disturbing element.

The Master Steam Fitters Association have a committee on standardization, and they were requested at their last meeting in Boston to take up that particular question, their committee has spent a good deal of time on it and have attempted to get in touch with us on the subject and they are here to-day. Instead of the Society stirring up trouble with the steam fitters or with the boiler manufacturers, if we can help to solve the problem we will cover ourselves with glory.

Mr. Seward: I have not seen any suggestion on the part of the manufacturers to this Society in regard to solving this problem. As a matter of fact I know the manufacturers have discussed it, and decided not to move in the matter at this time. I, however, think the time is ripe for this Society to say what are the standard operating conditions. The manufacturer is satisfied with what he has done, but the steamfitter is unable to discriminate between one boiler and another, notwithstanding that they are all sold at varying prices based upon their efficiency, so far as it has been determined. If this Society is not satisfied with the present state of affairs I think it should standardize the normal conditions, say what they are, and then let the manufacturer rate his boiler if he chooses, accordingly, not dictate to him, but tell him this is the standard method, and if you choose to rate your boiler under that standard it will be so recognized. Investigation of the proceedings of this Society shows there is more discussion on this subject than on any other single thing that has come before it. It started with the first meeting, and has continued ever since. The manufacturers six or seven years ago came together and adopted a method for rating heating boilers satisfactory to themselves. That method was read in the shape of a paper before this Society, and afterwards discussed, but generally ridiculed as being inadequate, and not definite enough, notwithstanding it answered the purpose at that time. This method has been eventually broken away from because the manufacturer has seen where he could improve the efficiency of his boiler and is entitled to a higher rating. It seems to me it is a very simple proposition. There is nothing to it other than somebody is entitled to determine the normal expectation as to coal consumption in domestic heating plants. When you specify coal consumption, and the manufacturer states his efficiency, you bring those two factors together, and you have the rating of the boiler. A standard rating is something that every engineer, every architect, and every steamfitter can understand, and whether the manufacturer adopts it or not, it can be used to level all boilers down to a common basis. I think this method would be fair to everybody, and this Society is the proper party to determine what the rate of coal consumption should be.

XUM

Mr. Vrooman offered the following:

Resolved, That it is the sense of this Society that in the absence of any standard for rating steam and hot water heating boilers, one should be established based on coal consumed per square foot of grate surface and efficiency.

Professor Carpenter: I would say respecting the manufacturers, I think they are anxious to have some standard adopted. I saw letters from two or three manufacturers, all of them referring to this question. One of the manufacturers evidently considered that his ratings were more than some of his competitors', and I think he felt if the other man did not raise his ratings he would probably lower his. At least I read that between the lines. I feel very certain if they would all adopt a standard of this kind you would not get into trouble, because they would be interested only in getting good results. Have the makers express their ratings so that we will understand what they mean.

President Mackay: This is of interest to the manufacturers of power boilers. The steamfitters have gone into it even farther. Mr. Kinealy has gone over it, and other members have gone over it, and it is proposed that we do something.

Mr. Nichols: I want to make an offer on behalf of the committee representing the National Association of Steam and Hot Water Fitters. It seems there is quite a difference as to the amount of fuel consumption that is expected from different boilers. We have discussed the matter at some length and desire to make this offer to the association. If you desire us to coöperate with you we will immediately start a series of tests, probably involving the tests of a hundred house heating boilers of various sizes in various parts of the country to determine the fuel consumption under ordinary conditions. We do not expect they will be scientifically correct, but they will be valuable information in future consideration of the exact amount of fuel consumption required in our tests.

Professor Kinealy: I assume, of course, that this motion will not tie the committee to any particular method of rating.

President Mackay: No; it does not. It suggests the necessity of having a standard for the amount of fuel a grate of given area will burn.

Mr. Nichols: For the information of the Committee on Standards, the committee of the Steam Fitters Association has been working now for nearly two years with another branch of the business without accomplishing very much. We have another factor to contend with. We have done our part, or at least all we can. We know how difficult it is to get others to come to you.

We are here simply to help you people all we can. It does seem the sooner we start the better it will be. Your committee as I understand it has spent considerable time already, and it certainly ought not take very long to get that information, and get your ideas in such shape that your committee could offer it either in its original or some modified form so as to secure accuracy.

CXCVIII.

AIR COOLING BY REFRIGERATION.

BY W. W. MACON.

(Member of the Society.)

To obtain the number of tons of refrigerating capacity needed in a refrigerating plant to cool an air supply from any given initial temperature and relative humidity to any desired temperature and relative humidity is the question which this paper plans to discuss, and the charts accompanying it are offered as a quick means for getting the result. Air cooling is seldom merely a case of air warming reversed. In air warming the vapor present is heated along with the air, but it has so little weight in comparison with the air that it is neglected in heating calculations. In air cooling, however, portions of the vapor must be extracted step by step, and this process requires the absorption of the heat of vaporization necessary to reduce the vapor to water. The heat of vaporization is relatively so large that the total heat involved in cooling air may be two or three times as much as that involved in warming the same amount of air through an equal range of temperature. In air cooling, therefore, humidity is an important consideration.

Heating 43.35 lb. of saturated air at ordinary atmospheric pressure from 82 to 83 degrees Fahrenheit means heating 42.35 lb. of dry air and 1 lb. of water in the form of vapor. Taking the specific heat of air at 0.238, and assuming that the specific heat of the vapor is the same as for water or unity, the addition of heat involved is $0.238 \times 42.35 + 1 = 11.08$ B. T. U. Cooling the same weight of saturated air from 82 to 81 degrees means a subtraction of heat of approximately $0.238 \times 42.35 + 0.026 \times 1050 = 10.08 + 27.3 = 37.38$ B. T. U., 0.026 being the weight, in a fraction of a pound, of the vapor condensed in the 1 degree drop, and 1050 being approximately the latent heat

of vaporization, or the heat corresponding to that effecting the change of state from liquid to gas or *vice versa*. It will be noted that over twice as much heat has to be extracted for liquefying the vapor as for cooling the air itself, and this explains the important difference between air cooling and air heating, and why it is so much more expensive to cool air than to warm it. Cooling air without bringing about the saturated condition is, of course, no different than air warming, but an air-cooling problem would always carry the conditions beyond this limitation.

THE HEAT EXCHANGES IN THE ROOM COOLED.

To maintain a room, as in summer, at a temperature below that outdoors means that a flow of heat will occur from the outside to the inside. The supply of heat will be augmented by the people present and by the lights burned. To keep down the temperature is the work of the air supply, which must be in sufficient quantity and sufficiently below the desired room temperature to absorb the heat supply without exceeding the room temperature before escaping. The refrigerating plant must then be chosen of a size equal to cooling the calculated volume of air from the outside temperature to a temperature low enough to take into account the warming up that the air may get before reaching the room. Some of the limiting considerations are that the volume of air must not be so great as to cause draftiness, nor must the individual be directly exposed to air currents at low temperature. The lower limit of air temperatures will naturally be dependent in part on the temperatures of the ammonia or brine-cooling coils, and on the depth of the coils in the direction of air flow and on the air spaces between and the velocity of flow through the coils.

Assume that a room is to be at 75 degrees when it is 90 degrees outdoors. The transmission of heat through the exposed walls for the 15 degrees range will be about $\frac{15}{20}$ or $\frac{3}{4}$ of what the transmission is at 70 degrees range, and it might figure that the average flow of heat through the walls is 8 B. T. U. per hour per square foot of the average exposed wall surface. If there is a large area of glass surface including skylights, through which the sun's rays can penetrate, account must also be taken

of this source of heat, regarding it, for example, as equivalent to adding 2 to 5 degrees to the outside temperature. That the animal heat from the individual is something of importance can be apprehended from the fact that the average individual will give off probably 400 heat units per hour. If the character of the walls and the relation of the actual glass surface to the total wall surface is such that the average transmission per square foot of the wall surface is about 8 B. T. U. per hour, it will be seen that each individual in the room is equivalent to an additional 50 sq. ft. of exposed wall surface. In other words, if there is a relatively large number of people to be accommodated in the room, the heat supplied from the human beings will be considerably greater than that coming in from the external sources.

Having ascertained the total amount of heat which will be supplied to the room interior under the extreme requirements for which the installation is to be designed, a measure is then had of determining the probable volume of air which should be admitted. This, of course, depends on the number of degrees through which the air is to be allowed to warm from the time it enters the room to the time it passes away. The determination of the proper number of cubic feet of air in a given time is a matter of arithmetic—the greater the range of temperature the less the volume. If a room is to be maintained at 75 degrees, and the air by which this is to be effected is to be allowed to warm, say, 10 degrees, it is obvious that the air must enter the room at a temperature approximating 65 degrees. As there will be an unavoidable rise in the temperature of the air in its transit from the air-cooling coils and the fan to the room inlets, the actual temperature to which the air must be reduced by the refrigerating installation must be below 65 degrees. Allowing 5 degrees on this account means that the air should be cooled by the refrigerating plant to about 60 degrees.

DETERMINING REQUIREMENTS OF REFRIGERATING APPARATUS.

Having ascertained the volume of air necessary by some such process as outlined in the foregoing, it remains to determine how much heat must be abstracted from the air supply to bring about the specified conditions and, therefore, how much refrig-

erating capacity will have to be provided in the refrigerating plant. Suppose the air received at 90 degrees Fahrenheit has a relative humidity as high as 80 per cent. Suppose also that it is desired to have the room air at a temperature of 75 degrees and a humidity of about 60 per cent. Either Chart I or Chart II can be used with these particulars, Chart II being the simpler and therefore more practical, but Chart I affording an opportunity to go into details. The important parts of Chart I are the sections A, B, C and D. Section C gives the number of British thermal units which must be removed from every pound of air to dispose of the excess moisture; section D gives the number of British thermal units per pound of air which must be removed to cool the air itself.

The point B in section A lies on the curve opposite the 75 degrees temperature, which it is desired to have within the space cooled. A line is run vertically downward from the point B until it is opposite the point in section B corresponding to a humidity of 60 per cent. A curved line is then traced parallel with the adjoining curved lines in section B until diagram A is again reached, when a line is run up vertically hitting the curve in diagram A at a point D which is found to correspond to a little above 60 degrees. The line is then run horizontally into section D, until it intersects the diagonal line corresponding to the initial temperature, in this case 90 degrees. From the point of intersection running vertically downward in D is obtained a point on scale 1, which shows that 6.9 B. T. U. are required for every pound of air received to cool it through the range of temperature stated.

The dotted lines corresponding to step 2 show that from the point A in the curve of section A opposite the 90 degrees initial air temperature is dropped a line until it terminates in section B opposite the 80 per cent. humidity of the air supplied. A curved line is then being traced parallel with the curved lines in B, until section A of the charts is again reached, when a line is run vertically upward to section C, and then run parallel with the diagonal lines of that section, as indicated in dotted lines. From the point D, already determined on the curve in section A, is continued a vertical line upward, as marked, this line continuing into section C until it intersects the diagonal just located in that section. From the point of intersection is run a

line horizontally to the scale at the left of section C, which shows the number of heat units required to effect the condensation of the moisture. In this case it is noted that for every pound of air 14.2 B. T. U. are required.

The total amount of heat, therefore, necessary to cool the air and to remove the moisture is equal to 6.9 + 14.2 = 21.1 heat units per pound of air. The sections of the diagram marked E, F and G can be employed to determine the amount of heat that must be removed to cool the varying quantity of moisture from the initial temperature to the final temperature, but, as will be shown, this amount of heat is relatively small, probably averaging about 2 or 2½ per cent. of the amount of heat just determined. Thus for a ready estimation of the amount of heat which must be removed, we may add 2½ per cent. to the 21.1 heat units, making a total of 21.6 heat units for every pound of dry air.

From this figure the capacity of the refrigerating plant in terms of so-called tons of refrigeration can, for every 1,000 cu. ft. needed per minute, be obtained by multiplying the number of heat units found by the charts by 0.35. For example, suppose that 6,600 cu. ft. of air are required per minute. For the case in hand the heat that must be abstracted per pound of dry air is equal to 21.6 B. T. U. Multiplying 21.6 by 0.35 gives 7.56 tons of refrigerating capacity for every 1,000 cu. ft. required per minute. Multiplying this by 6.6 shows that the total refrigerating capacity is 49.9 tons, or, say, 50 tons.

Section A of Chart I shows that to get the air finally at 75 degrees with 60 per cent. humidity, the refrigerating plant must be able to cool the air to about 60.5 degrees. This means that after the refrigerating plant has done the work of cooling the air to very nearly 60 degrees, the air can be warmed almost 15 degrees, which fact is merely a coincidence allowing for the 5 degrees rise in the air temperature before the room is reached and the 10 degrees after the air enters the room. The logical way would have been to take the low temperature at 60 degrees, with the humidity 100 per cent., inasmuch as the air must always leave the refrigerating coils saturated, and then to note if a desired condition of humidity would exist at the room temperature. If too high humidity is likely to result, the air will have to be cooled to a greater extent and the calculations modi-

fied accordingly. This point will be referred to in connection with Chart II, but its important bearing is explained in the following:

For example, suppose it is desired to employ a smaller quantity of air than such a calculation as the foregoing indicates as necessary. Then the air will have to be cooled to a lower point. Suppose that the air is cooled by the refrigerating plant to 55 degrees, and assume also that the air as it passes through the ducts is warmed about 5 degrees. Then the air after admission into the room can be warmed 15 degrees before a temperature of 75 is exceeded. From the charts it will be found that 8.4 B. T. U. must be absorbed for cooling each pound of air from 90 degrees to 55 degrees, and that about 16.4 B. T. U. are required to condense the vapor. This makes a total of 24.8 B. T. U., which, increased by 2½ per cent. for the cooling of the vapor itself, gives a total requirement of 25.4 B. T. U. per pound. This shows that more refrigeration is needed in this case per pound of air in the ratio of 25.4 to 21.6, but as the air can be warmed 15 degrees after its entrance into the room as against 10 degrees in the case first considered, only two-thirds as much air is needed, and therefore the required capacity of the refrigerating plant is in the ratio of $\frac{2}{3}$ of 25.4, of 16.9 to 21.6. In other words, the refrigerating plant when the air is cooled to 55 degrees is only 78 per cent. as large as that cooling the air to 60 degrees, owing to the smaller volume of air sufficing. These figures show the value of moving a minimum volume. There is, of course, a limit depending on the degree of ventilation which the room must have, the minimum amount of air necessary for a proper diffusion of the air and the limiting temperatures which one can obtain in an economically operating refrigerating plant.

Another point to be mentioned in this case is that if the air is cooled to 55 degrees and then warmed to 75 degrees the final humidity at 75 degrees instead of being at 60 per cent. will be about 50 per cent. This would in the average case be cause for satisfaction, the desired point being that room humidity must not exceed 60 per cent. It is the selection of the range through which the air can be warmed after it is cooled by the refrigerating plant that governs in some measure the relative humidity which the air will have finally in the room. When the

air is cooled by the refrigerating plant to 60 degrees, there is present in it all the aqueous vapor that can exist at that temperature, and the weight of vapor remains constant as the air passes over no water, and it has no opportunity for acquiring further moisture. The relative humidity which the air will have will depend on the range of temperature through which it is warmed. The only factor that affects it slightly is the moisture given to the room air by the individuals in the products of respiration and by gaslights in the combustion of the hydrogen content. The average supply of moisture by the human body is $\frac{1}{15}$ lb. per hour. The introduction of, say, 2,000 cu. ft. of air per hour per individual from a cooling plant carrying the air to, say, 55 degrees, means an hourly supply of 1.4 lb. of aqueous vapor in the air as compared with about 0.06 lb. added from the individual.

MATHEMATICS OF AIR COOLING.

The cooling of air involves the following four steps: 1, the cooling of the air from initial temperature to final temperature; 2, the cooling of the vapor contained in the air until the temperature is reached when the air becomes saturated; 3, removing the heat necessary to bring about the gradual liquefaction of the part of the vapor that must be disposed of; 4, the cooling of the vapor that remains in the air from the temperature when the air first becomes saturated to the final temperature.

The amount of heat that must be removed to cool 1 lb. of dry air or B_1 is equal to $0.238 \times (T - t')$, where 0.238 is the specific heat of air, and T and t' are the initial and final temperatures of the air.

The amount of heat removed to cool the vapor until the air becomes saturated is, for every pound of air, $B_2 = H\ W \times (T - T')$, where H represents the percentage of humidity in the air at temperature T, W represents the weight, in a fraction of a pound of the vapor present with a pound of air when saturated at temperature T; and where T' represents the temperature at which vapor will first begin to condense if the temperature is lowered. It is assumed that the specific heat of the aqueous vapor is equal to that of water or unity.

After the point of saturation of the air is reached, it is ob-

vious that each small drop in temperature means that a small part of the vapor is condensed, leaving the air always in the so-called saturated condition with a gradual condensation of the vapor as the temperature is lowered. In the diagram, Fig. 1,

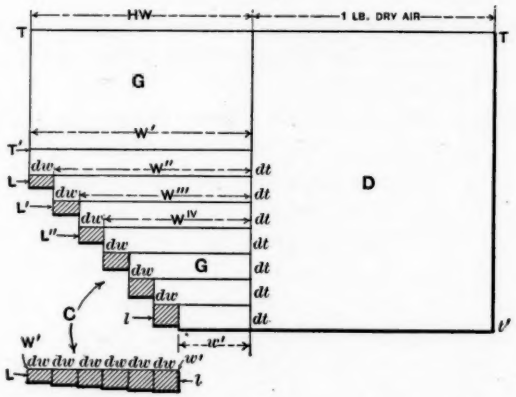


FIG 1.—DIAGRAM TO SHOW STEPS IN COOLING AIR.

$H\ W$ represents the actual amount of vapor present with every pound of dry air as the air is received by the refrigerating plant, W being the weight of vapor with one pound of air when saturated at the out-door temperature, and H being the percentage of saturation or the relative humidity. As the temperature is lowered this weight of vapor naturally remains constant (although it will occupy less space, as will also the pound of air at the lower temperatures, due to contraction), until a temperature, designated by T', is reached when $H\ W = W'$ or the weight of vapor which makes 1 lb. of air saturated at temperature T'.

For subsequent reduction in temperature let the vertical distance marked dt represent a very small drop in temperature. Then the rectangle, which is equal to the area of $W' \times dt$, represents the amount of heat abstracted when this weight of vapor is cooled through the very small drop in temperature. When an attempt is made to subject the vapor to a further drop in temperature, a small amount of the vapor designated by dw is condensed, leaving an amount of vapor represented by W''.

Then the area represented by the product of W'' and dt represents the amount of heat to be taken away in cooling W'' lb. of vapor through a small drop in temperature. On the next small drop in temperature another small amount of vapor is condensed, and the process can be imagined as taking place in successive steps until the final temperature desired is reached, when the amount of vapor existing is represented by the line w'. Obviously the area of the long rectangles represents the total amount of heat taken from the vapor.

In a similar way the small shaded rectangles represent the amount of heat abstracted in effecting the condensation of the vapor. If we multiply each small amount of moisture that is condensed by the latent heat of the vapor at that temperature, the product will be the amount of heat that has to be abstracted in each case. As the temperature is reduced the latent heat of vaporization rises slowly, and this is indicated in the shaded sections. The area of the white rectangles, inasmuch as the little offsets dw are very small, is equal to the area of a trapezoid, of which W' and w' are the bases, and of which the altitude is the sum of all the small drops in temperature, which sum in turn is equal to the difference between T' and t'. In other words, the area in the white rectangles, or the amount of heat which must be abstracted in cooling the gradually decreasing weight of moisture, is equal to

$$(W'' + w') \times \tfrac{1}{2} (T' - t') = B_3.$$

If we arrange the black rectangles as shown separately in Fig. 1, it will be seen that their collective area is also that of a trapezoid; that is, that the amount of heat required to condense the moisture is equal to

$$\Sigma\, dw \times \tfrac{1}{2} (L + l) = (W' - w') \times \tfrac{1}{2} (L + l) = B_4.$$

CONSTRUCTION OF CHART I.

Chart I is made to give the results for these various equations. Section A is a curve based on figures given in tables on the properties of air such as are commonly found in books on heating. It shows the relation between the amount of vapor existing with 1 lb. of dry air saturated and the temperature of the

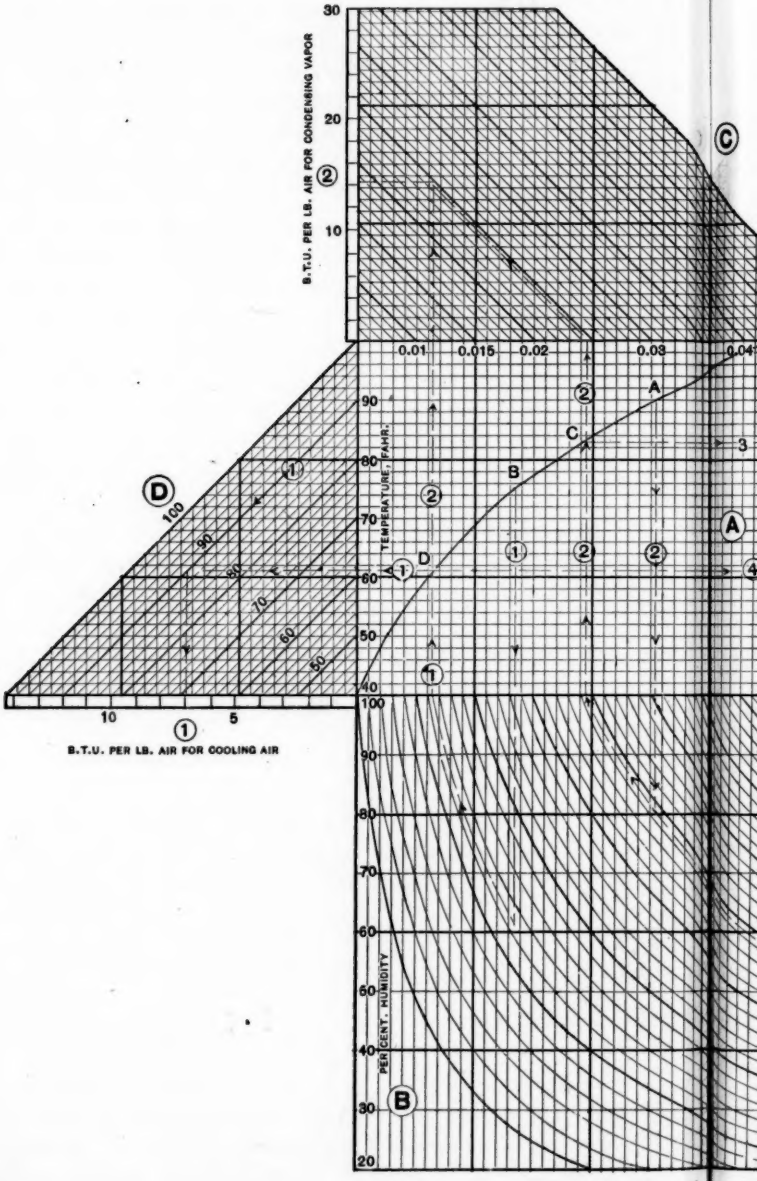
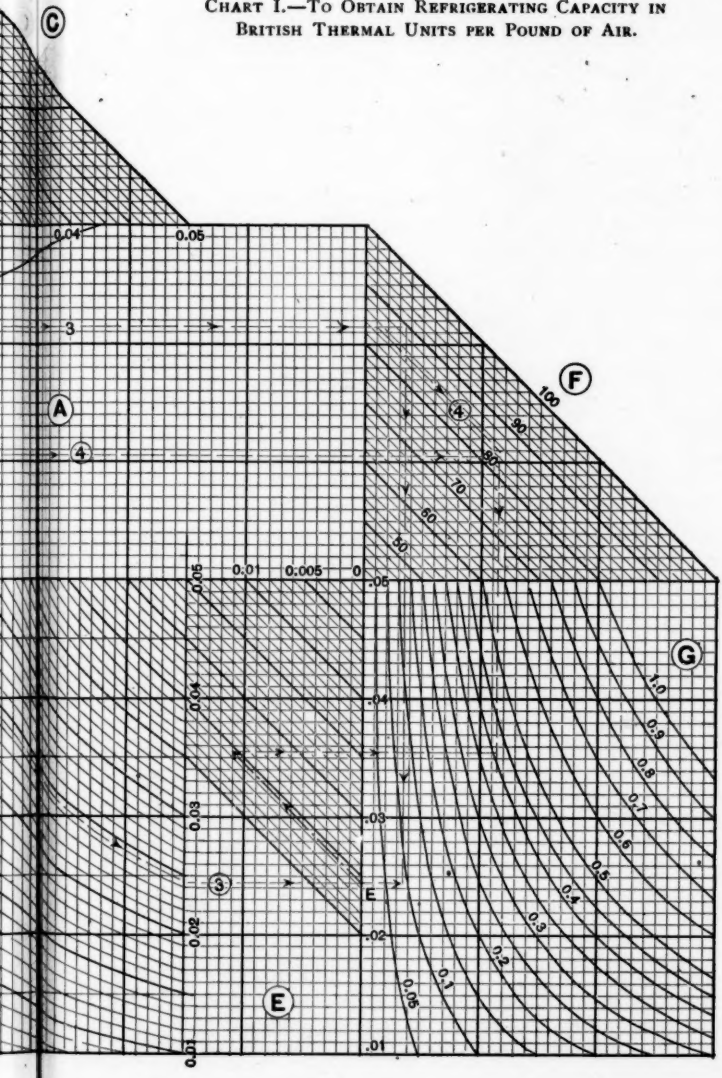

B.T.U. PER LB. AIR FOR CONDENSING VAPOR
30
20
10
②
C
0.01
0.015
0.02
0.03
0.04
TEMPERATURE FAHR.
90
80
70
60
50
40
A
B
C
D
3
4
100
90
80
70
60
50
10
5
①
B.T.U. PER LB. AIR FOR COOLING AIR
PER CENT. HUMIDITY
100
90
80
70
60
50
40
30
20

CHART I.—TO OBTAIN REFRIGERATING CAPACITY IN BRITISH THERMAL UNITS PER POUND OF AIR.



air. Section B is a group of equilateral hyperbolæ, each of which is the locus of points, the products of the coördinates of which is a constant, the coördinates representing the percentages of humidity and the weight of vapor per pound of air. In other words, the equation of the curves in section B is $H\ W =$ constant. Section C is arranged with diagonal lines, so that by using as indicated by the dotted lines the difference in the weight of vapor in the air at any two points of temperature can be ascertained. Section C is to get the value of the equation $B_4 = (W' - w') + \frac{1}{2}\ (L + l)$. As the difference between the values of the latent heat is small, particularly over the range which problems of this character cover, a value of 1,070 B. T. U. per pound of vapor was taken as the mean value of L and l, and the scale to the left of section C of Chart I is made to read directly in products of 1,070 and the weight of vapor removed from the air.

Section D is also arranged with diagonal lines, so as to give a reading for the difference in initial and final temperature. The scale immediately below D represents the product of this difference in temperature and the specific heat of air, so as to give a reading directly in the number of heat units necessary for cooling every pound of air. This gives the value of B_1.

Section G is used to obtain both the amount of heat required to cool the vapor from initial temperature to the point when the saturation begins, and to obtain the heat required in cooling the vapor after the first point of saturation is reached. The curves of section G are also equilateral hyperbolæ, with differences in temperature as one of the coördinates and the weights of vapor as the other. In determining the amount of heat required to cool the vapor in the first process the figures of the curves must be multiplied by 2. The dotted lines numbered will indicate the application of the curves in section G.

From the point C in the curve of section A, which point corresponds to the temperature when the air becomes saturated, and which point was determined as explained, a line is run horizontally, as marked in the dotted lines, to section F, until the diagonal line corresponding to initial temperature is reached, when the line is dropped vertically downward into section G. This is intersected by a line drawn from section B horizontally from the end of the curve representing the amount of vapor ex-

isting with 1 lb. of air at the initial temperature. The point of intersection lies on a curve, the value of which in the present example would seem to be 0.08. Multiply this by 2, and the result will be the number of heat units which must be abstracted per pound of air to cool the vapor in the air from initial temperature to the temperature when saturation occurs. This corresponds to the equation $B_2 = H\ W\ (T - T')$.

The fourth step involves following a horizontal line in section A from the point D, the final temperature to which the air is brought, carrying this line into the section F until it intersects the diagonal line corresponding to the temperature when the air first became saturated. From this intersecting point a line is dropped into section G. This vertical line corresponds to one-half the difference in temperature between the air when first saturated, and when it finally leaves the refrigerating surface, and is part of the equation $B_3 = (W' + w') \times \frac{1}{2} (T' - t')$. The sum of the vapor contents per pound of air is obtained in the following manner: The line 3 in section E corresponds to the vapor existing in the air as it is received by the refrigerating plant; that is, the amount of vapor existing per pound of outside air. From the point E a line is run at 45 degrees in section E, as indicated, until a vertical line is reached corresponding to the amount of vapor existing at the final temperature, this figure being obtainable from section A in the dotted line marked 1. When this diagonal line in section E reaches this vertical line, a line is run horizontally into section G. Its intersection with the vertical line from section F gives the point desired. This, it will be noted, lies on the curve corresponding to 0.41, meaning that 0.41 heat unit must be abstracted from every pound of air in order to cool the vapor from the temperature at which saturation occurs to the final temperature, and is the value of B_3.

The sum of B_2 and B_3 shows that 0.57 heat unit should be added to the 21.1 heat units covering $B_1 + B_4$, or that the total heat requirement per pound of air is 21.67. This indicates that the amount of heat shown as necessary by the sections C and D, of Chart I, is increased 2.7 per cent. to take into account the cooling of the vapor.

After ascertaining the number of heat units required per pound of air to cool it, it is next desired to know the refrigerat-

ing capacity. As the figures are obtained per pound of air, and as the weight of dry air in 1 cu. ft. of a mixture of air and vapor depends not only on the temperature of the air, but on the relative humidity, it would seem necessary to multiply the number of heat units found by the chart by the weight of dry air in 1 cu. ft. of the outside air to ascertain the number of heat units required in the refrigerating plant per cubic foot of the air supplied. It is obvious that the refrigerating capacity should be given in terms of the number of cubic feet of air which must be supplied. The weight of the dry air in a cubic foot of a mixture of vapor and air varies from 0.0659 for air at 102 degrees and 100 per cent. humid to about 0.074 lb. per cubic foot for air at 72 degrees and 50 per cent. humid. The variation at the average temperatures and percentages of humidity is not great, so that the number of heat units required per cubic foot would be closely approximated by multiplying the heat units found by the charts by 0.07. However, a table approximately correct has been prepared to show the variation of the weight of the dry air in 1 cu. ft. of different mixtures of air and vapor at different temperatures.

WEIGHT OF DRY AIR IN 1 CUBIC FOOT OF MIXTURE OF AIR AND VAPOR.

TEMP.	PERCENTAGE OF HUMIDITY.						
Deg. Fahr.	100	90	80	70	60	50	0
102	0.0659	0.0664	0.0669	0.0674	0.0678	0.0683	0.0707
92	.0684	.0687	.0691	.0694	.0698	.0702	.0720
82	.0706	.0708	.0711	.0714	.0717	.0720	.0733
72	.0727	.0729	.0731	.0733	.0735	.0737	.0747
62	.0747	.0748	.0750	.0751	.0753	.0754	.0761
52	.0766	.0767	.0768	.0769	.0770	.0771	.0776
42	.0784	.0785	.0785	.0786	.0787	.0788	.0791

If we multiply the total volume of air required, say, in a minute's time, by the weight of this air in pounds per cubic foot, as shown in the table, and multiply this in turn by the number of British thermal units found necessary per pound by the charts, the final product will give the total number of heat units which must be removed in the given time. If we divide this by the heat equivalent of 1 ton refrigeration the quotient will give the refrigerating capacity. One ton refrigeration may be defined as being equal to the heat transfer involved in the freezing or melting of 2,000 lb. of ice in 24 hours. The latent heat of ice, that is, the number of heat units which must be abstracted from water after it has reached the point of freezing

before ice is formed, is equal to 142.2 B. T. U. For 2,000 lb. this represents 284,400 B. T. U. per day, or about 12,000 B. T. U. per hour, or 200 B. T. U. per minute. In other words, 1 ton refrigerating capacity for one day is equivalent to the performance of 200 B. T. U. every minute. If we divide the total heat requirements as calculated by 200, the result will be as stated, the refrigerating capacity required. If we take the average weight of the dry air in a cubic foot of the average mixture of vapor and air out-doors in summer as 0.07 lb., every 1,000 cu. ft. of air handled per minute represents 70 lb. of air to be handled by the refrigerating plant every minute. If one heat unit of refrigeration is required for every pound of air admitted to the system, then 70 heat units will be required per minute per 1,000 cu. ft. per minute. Dividing the 70 heat units by 200 heat units corresponding to 1 ton refrigeration gives a quotient of 0.35 as the number which multiplied by the heat requirements of 1 lb. of air gives the number of tons refrigeration per thousand cubic feet of air per minute.

APPLICATION TO NEW YORK STOCK EXCHANGE.

A practical application of the charts may be had in connection with the refrigerating plant which has been installed in the New York Stock Exchange. This equipment is one of the particularly interesting features of the mechanical plant designed for that building by Alfred R. Wolff of New York City. It was described at length in four issues of the *Engineering Record* in April, 1905, and in respect to its air-cooling plant alone in *The Metal Worker* of August 5 of the same year. The plant is notable not alone for its magnitude, although of no less than 450 tons' refrigerating capacity in three units, but for the fact that it represents a solution of the problem of cooling air for ventilation on a scale not considered up to that time.

The articles mentioned explain that the apparatus is provided to secure a room temperature of not more than 75 degrees and a humidity of about 55 per cent when air received at 85 degrees Fahrenheit and 85 per cent. humidity. In Chart II we locate two points, one on a line opposite 85 degrees and midway between the curved lines corresponding to 80 and 90 per cent.

humidity, and the other on a line opposite 75 degrees and midway between the curved lines corresponding to 50 and 60 per cent. humidity. The first point corresponds to the condition of the outside atmosphere, and the second to the condition which it is desired to have inside. From the latter point is dropped a

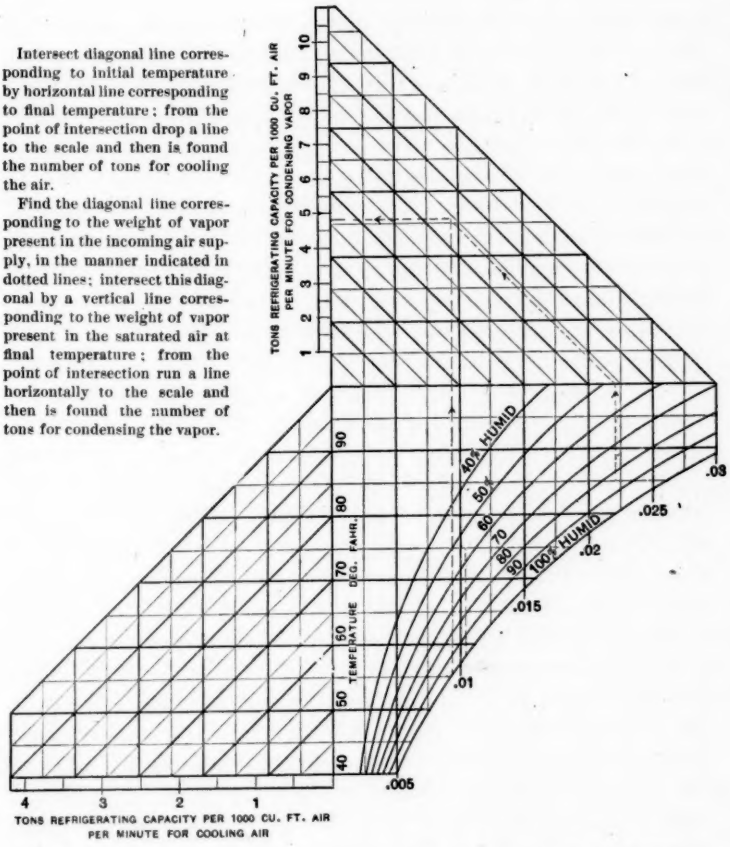

Intersect diagonal line corresponding to initial temperature by horizontal line corresponding to final temperature; from the point of intersection drop a line to the scale and then is found the number of tons for cooling the air.
Find the diagonal line corresponding to the weight of vapor present in the incoming air supply, in the manner indicated in dotted lines; intersect this diagonal by a vertical line corresponding to the weight of vapor present in the saturated air at final temperature; from the point of intersection run a line horizontally to the scale and then is found the number of tons for condensing the vapor.
TONS REFRIGERATING CAPACITY PER 1000 CU. FT. AIR PER MINUTE FOR CONDENSING VAPOR
1
2
3
4
5
6
7
8
9
10
TEMPERATURE DEG. FAHR.
90
80
70
50
40
40% HUMID
50%
60
70
80
100% HUMID
.03
.025
.02
.015
.01
.005
4
3
2
1
TONS REFRIGERATING CAPACITY PER 1000 CU. FT. AIR PER MINUTE FOR COOLING AIR

CHART II.—TO OBTAIN REFRIGERATING CAPACITY DIRECTLY IN TONS

line until the curve corresponding to 100 per cent. humidity is reached. This point will be found to lie opposite 58 degrees, and indicates the temperature to which the air must certainly be reduced to bring about the desired conditions. Running hori-

zontally from this point into the group of diagonal lines until the diagonal line corresponding to the initial temperature of 85 degrees is reached gives a point, which by dropping a line to the scale shows that 2.3 tons' refrigerating capacity are required in the refrigerating equipment for cooling the air for every thousand cubic feet which may be required per minute.

To determine the number of tons necessary for condensing the vapor a line is carried vertically upward from the point corresponding to outside air conditions until the upper group of diagonal lines is reached, when this line is then carried parallel with the diagonal lines. From the point corresponding to inside conditions a line is carried up vertically until it reaches the diagonal line just located, and the point of intersection will be found to lie opposite a position on the scale corresponding to 4.35 tons' refrigerating capacity. The total is thus 6.65 tons, which should be increased 2½ per cent. to take care of the cooling of the vapor, making a total of 6.82 tons for every thousand cubic feet required per minute.

It is stated that the hourly amount of heat added to the board room of the building, comprehending the heat transmission from outside atmosphere through the windows, doors, outside walls and skylights, and taking into account also the heat from the sun, the animal heat from individuals within the room and the heat from lights which may be burning, is altogether about 666,000 B. T. U. If we assume that the air after it leaves the refrigerating plant is warmed 5 degrees before it enters the room, it reaches the board room at a temperature of 63 degrees. As the air is not to exceed 75 degrees within the board room, the air supply which is to offset the heat in the room can be warmed through $75 - 63 = 12$ degrees. One cubic foot of air heated 12 degrees takes up $1 \times 12 \times 0.075 \times 0.238 = 0.214$ B. T. U. The 666,000 B. T. U. supplied in an hour is equal to 11,100 B. T. U. in a minute, therefore the air supply needed in a minute is equal to $11{,}100 \div 0.214 =$ about 51,800 cu. ft. per minute. The refrigerating capacity under these conditions would, therefore, be equal to $51.8 \times 6.82 = 353$ tons' refrigerating capacity. The relative humidity, however, will really be more than 55 per cent., inasmuch as the individuals are moisture producers, and if there are gaslights an additional amount of moisture will also be added from this source. We

may, therefore, see what the effect will be of reducing the air to a temperature of 55 degrees in the refrigerating plant.

By referring to Chart II it will be found by running horizontally along the line corresponding to 55 degrees until it intersects the diagonal line corresponding to 85 degrees that 2.55 tons are required for cooling 1,000 cu. ft. of air per minute. Similarly a line is run vertically upward from the point on the 100 per cent. humidity curve corresponding to 55 degrees, until this vertical line intersects the diagonal line corresponding to the 85 degree 85 per cent. humidity point. The point of intersection shows that 4.8 tons' refrigeration are required for condensing the vapor. The total, adding 2½ per cent for cooling the vapor, is 7.53 tons per thousand cubic feet of air per minute. In this case we may assume the air is introduced into the board room at 60 degrees, with the opportunity of warming 15 degrees further during the process of supplying the heat to the board room. Warming each cubic foot of air 15 degrees is then equal approximately to 0.268 B. T. U. Therefore the number of cubic feet of air required in a minute is equal to 11,100 ÷ 0.268 or about 41,400 cu. ft. Therefore the size of the refrigerating plant necessary is equal to $41.4 \times 7.53 = 312$ tons. There were provided for the board room two 150-ton refrigerating plants, or 300 tons altogether.

Pipe coil surface is employed for cooling the air, and for the board room just described there are 20,000 linear feet of 1¼ in. galvanized pipe. This bunker of pipe coil surface is arranged in 22 coils, each coil lying horizontally with the supply and return ends of the 22 coils connected into two vertical headers. The coils are of continuous piping from supply to return header bent in serpentine form, which brings the pipe back and forth across the bunker chamber. The entire bunker occupies a space of about 10 ft. in depth in the direction of air flow and 18 ft. transversely with respect to the air flow. The connections of the coils to the header are spaced about 4½ in. on centres, and the paralleling or serpentine form of the pipes of each coil brings the piping in two layers or levels, so that the pipes are roughly centre to centre measurement from the bottom to the top of the bunker chamber about 2½ in. apart, with the pipes disposed in 44 layers. There is a free cross section for the flow of air of perhaps 45 or 50 sq. ft., and with the de-

livery by the fans of 41,400 cu. ft. per minute the velocity through the bunker chamber approximates on this basis 900 to 950 ft. per minute.

The 20,000 linear feet in the bunker for the board room represents 8,700 sq. ft. of heat-absorbing surface. The 312 tons of refrigerating capacity just figured means that the bunker is to absorb in one hour's time $312 \times 12{,}000 = 3{,}744{,}000$ B. T. U. Dividing this by the number of square feet indicates that each square foot of the bunker surface is depended on to absorb about 430 B. T. U. per hour. With air received at 85 degrees and discharged at 55 degrees, the average temperature of the air is 70 degrees. If the brine circulating through the coils is delivered at zero, and leaves the coils at 10 degrees Fahrenheit, the mean temperature of the brine would be 5 degrees. The difference in temperature between the mean temperature of the brine and the mean temperature of the air is thus 65 degrees. This would, therefore, mean that each square foot of the bunker surface is calculated to absorb somewhere in the neighborhood of 7 B. T. U. per square foot of bunker surface per hour per degree difference in temperature between the air and the cooling medium. If the brine should average as high as, say, 20 degrees, the difference between the mean air temperature and mean brine temperature would be 50 degrees, and the amount of heat absorbed by each square foot of the bunker surface per hour per degree difference would approximate 8 B. T. U. It appears also that the refrigerating machinery in the Stock Exchange, which is of the ammonia-absorption type, is operated entirely with exhaust steam from the mechanical plant at not over 4 lb. pressure above the temperature, and that the water used in the apparatus is used in part for boiler feed purposes and in part for supplying the plumbing fixtures of the building.

DISCUSSION.

Mr. Weinshank: About two years ago I mentioned the subject to the Society, and at that time the matter was treated very lightly by the Society, as but little information was at hand. I am glad that Mr. Macon has gone into the subject and brought

out points which will enable us to treat the matter more accurately. I hope that the Society will keep this matter up until the problem is solved from a practical standpoint.

About eight years ago this subject of cooling caused the writer considerable trouble when he undertook to dry photographers' film paper. The only practical way of drying this paper is by condensation of moisture or by sending it through a cooling room. To accomplish this, I designed a tunnel 90 ft. long, 4 ft. wide and 7 ft. high. The paper was unrolled from a large roller and sent through the room slowly, and by keeping the temperature of 34 degrees above zero I was able to dry the paper by the time it reached the farthest end of the tunnel.

To determine the amount of ice required to cool the air in the room from 80 degrees F. outside to 34 degrees F. inside, and at the same time change the air in the room every minute, I had to conduct a series of tests and by a number of trials finally succeeded in procuring results, but was not in a position to determine beforehand the size of apparatus required, not having any data at hand.

I am glad that this matter is being treated by the Society, and I was very much pleased with the tests made by Mr. Feldman, and hope that others who are in a position to do so will continue the good work. If we were placed in a position where we can control the conditions of air, I possibly would be able to answer a physician's question.

I was asked by a physician why I could not create artificial air such that they could build hospitals and provide same with such air as would compare with the climate in Arizona or Colorado, where we usually send our friends afflicted with tuberculosis. When I informed the doctor of the costs, he replied that if we could save ten lives a year it would be worth all the expense for the maintenance of such hospitals if such could be accomplished.

Professor Kinealy: I think we ought to be congratulated upon this paper of Mr. Macon's. It is an excellent paper. There is a demand now for heat during the winter and cold during the summer.

Mr. Lyle (Carrier Air Conditioning Co.): I understand the floor is open to outsiders. I am interested in this paper from

the fact I have been interested in some work along these same lines.

Many physicians who are studying conditions of tuberculosis, throat diseases and nasal diseases, are taking up the theory and view that the dry air has little to do with the cure of these diseases; that it is not a question of low percentage of relative humidity, but a question of a standing condition, and, as a result of that they tell me that the cures of consumption effected on Blackwell's Island, surrounded with water and a high percentage of humidity all the time, compare favorably with the results obtained in Arizona. They have turned out a great many cures at the city hospital.

To go back to Mr. Macon's paper, I would like to ask what back pressure he uses approximately, and how much water is used on the New York Stock Exchange job.

Mr. Macon: I understand so far as back pressure is concerned they never used to go above four pounds. I suppose that is in the warmest kind of weather. I believe they start that plant at 8 or 9 o'clock every morning, not running at all during the night. They stop before the Exchange closes. The brine probably reaches at the end of that period 20 degrees. When it comes to getting any figures from the Exchange they refuse to give them. I assume that some of the data on their plant have been advertised in a way that the Exchange does not like. I am willing to add this much to the paper. The contract conditions with respect to the performance of the refrigerating machinery definitely stated how much minimum and maximum quantity of steam would be necessary for one ton of refrigeration, meaning that the water had to be hot enough to absorb the amount of heat taken out of the air and also the amount of steam that is condensed. Going into it roughly we may assume that more heat energy has to be represented in the steam supply than the heat energy that is taken out of the air before you can have the 100 per cent. efficiency. So it is obvious that the amount of heat energy has to be more than twice the amount of energy represented for the cooling of the air. This means a maximum condition of 1,000 tons refrigerating capacity at the twenty-four hour basis. We must remember the plant is not run twenty-four hours. One ton of refrigerating capacity

means the heat abstracted in making 2,000 pounds of ice or about 280,000 B. T. U. every twenty-four hours.

Mr. Lyle: Do you have any trouble with moisture freezing on the coils, or does shutting down through the night throw this off so they won't give you any trouble during the day's run.

Mr. Macon: No.

Mr. Feldman: Usually in these large plants that only run a few hours in the day and that never get below 25 degrees in the brine, the coils never have a chance to get any frost on them at all.

CXCIX.

NOTES ON THE DESIGN OF FURNACE HEATING SYSTEMS, WITH AN APPLICATION TO A TEN-ROOM RESIDENCE.

BY J. D. HOFFMAN, LA FAYETTE, IND.

(Member of the Society.)

1. The heating of the buildings in which we live is a subject that has of late been fortunately receiving considerable attention in all parts of the country. Improved conditions of living and more expensive buildings have demanded it. In the recent rapid growth of this branch of engineering, different systems have been compared, not only as to cost of installation, but as to satisfaction and economy of operation. Such investigations stimulate competition and improve the product, hence they are to be commended. Some of the comparisons, however, have been difficult to sustain because of the different bases upon which these systems have been operated. For instance, the efficiency of a direct radiation steam or hot-water system having no arrangement whatever for admitting fresh air to the rooms for ventilation, should not be compared to that of a furnace-heating system having an outside air connection and supplying fresh air to the rooms for ventilation; the one is not only heating the building, but is heating the cold air which enters the building, the other is merely heating the building. Conditions in each case should be the same before we can make any very definite comparisons. Of course, general statements may be, and are, frequently made, but they are understood to be only approximately correct.

2. Some of the points in favor of the furnace system are: First, low cost of installation; second, heat combined with ventilation; third, the rapidity with which the system responds to light service or to sudden changes of out-door temperatures.

Compared with that of steam-heating systems, the furnace plant can be installed for one-half to one-third the cost, and from one-third to one-fourth that for hot-water systems. In addition to this, the fact that ventilation is so easily obtained, and the fact that a small fire on a mild day may be used to remove the chill from all rooms, gives this method of heating many advocates.

3. The objections to the system are: First, cost of operation; second, the difficulty of heating the windward side of the house; third, the contamination of the air supply by fuel gases leaking through the joints of the furnace. In a good system, well installed, however, the only serious objection is the difficulty of heating that part of the house subject to the pressure of heavy winds. The stack draft from a warm-air furnace is not very strong at best, and any differential pressure in the various rooms would tend to force out the air from certain rooms towards those having the least resistance. The cost of operating can be controlled to the satisfaction of the owner, consistent with his ideas of the quantity of ventilating air needed. For example, in any plant arrangements should be made to carry the cooled air from the room back to the furnace to be reheated. In this case, if the outside ventilating air be cut off entirely, the cost of heating is about the same as that of any ordinary system of direct radiation, having no provision for ventilation. On the other hand, any amount of pure air up to the full amount may be taken from the outside for the purpose of ventilation, requiring, of course, that the same amount of air be exhausted at the room temperature. The process, therefore, of exhausting this air for the sake of obtaining good ventilation is where the excess cost of furnace heating comes in.

4. The real object of this paper, therefore, is to discuss one type of system only—i.e., furnace heating in residences. In this we will consider the various points of design and operation, work out such formulas as may be applied to other systems of the same type and apply these formulas to a typical case.

5. Ventilating Air Needed per Hour.—The need of a continuous supply of fresh air in our residences can scarcely be over-estimated. Health is probably the greatest of all blessings, and pure air is an absolute necessity to health. The

human body has been compared to a well equipped, although very complex, power plant. As the carbon, hydrogen and oxygen of the fuel and air supply in any mechanical power plant is consumed in the furnace, the resulting heat being absorbed in the generating system and finally turned into work through the attached mechanism, so the human body in a similar way, but at a very much slower rate, absorbs the heat of combustion and turns it into work. The products of combustion in both cases are largely carbonic acid and water. The chief requisites of the mechanical plant are good fuel, good draft and good stoking. On the other hand, the human body needs pure food, pure air and healthful exercise. Of the three, the second is probably of the greatest importance, since no person can keep in health with impure air, even though accompanied with the best food and plenty of exercise.

6. The oxygen of the air fills about one-fifth of the volume in atmospheric air and is the element that makes combustion possible. When rejected as a carbonic acid, CO_2, it carries away the impurities from the body and cleanses the system. The amount of CO_2 in the air is used as an index to the purity of the air, pure air having four parts CO_2 in 10,000 parts of air. The average person gives off probably .6 cubic foot of CO_2 in one hour, from which, if the impurity of the air in the room be maintained at six parts CO_2 in 10,000 parts of air, the person will need 3,000 cubic feet of atmospheric air per hour; if maintained at eight parts in 10,000, the person will need 1,500 cubic feet per hour. This may be put in a simple form for calculation:

Let V = cubic feet of atmospheric air needed per hour per person; A = cubic feet of CO_2 given off per hour per person; n = the standard of purity to be maintained (allowable parts of CO_2 in 10,000 parts of air); and p = the standard of purity in atmospheric air, say, 4; then

$$V = \frac{A}{n - p} \qquad (1)$$

from which the curve (Fig. 1) is developed.

7. It should be understood that no hard and fast rule can

be given for the air required per person. This naturally would be a different amount when considering the physical development of each person in health; it would also be different for the same person, according to his occupation at the time; also, according as the degree of purity within the room is maintained, the air supply must be changed to suit. Eighteen

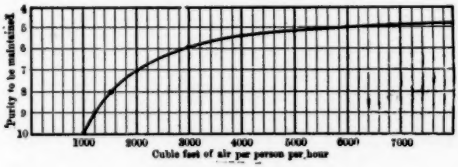


FIG. 1.

hundred cubic feet per hour per person has become quite generally accepted and will be assumed in this case. In addition to the vitiation of the air by the occupants, there are more or less impurities coming from gas burners, lamps, etc. This may be accounted for in terms of occupants of the room. It is claimed that one ordinary gas burner using, say, four cubic feet of gas per hour will vitiate as much air as three or four people. Where many lamps or gas burners are used, they should be accounted for by increasing the fresh-air supply accordingly.

8. AIR CIRCULATION IN FURNACE HEATING.—The use of air in furnace heating may be considered from two standpoints, each very distinct in itself. First, *air as a heat carrier;* second, *air as a health preserver.* The first may or may not provide fresh air; it merely provides enough air to carry the required amount of heat from the furnace to the rooms, *i.e.*, to take the place of the heat lost by radiation plus the small amount that is carried away by the natural interchange of air from within and without the building, as would be true in any residence that is not especially planned to provide ventilation. With certain allowable temperatures at the various parts of the system, this volume of air may easily be calculated. One point here should be remembered. When the cubic feet of air per hour as a heat carrier is found, the volume remains the same, no matter if it enters the furnace through a duct from within or without the building. So this plan may be both a *heat carrier* and a *venti-*

lator if desired, *subject only to the amount of air required.* The second plan requires that enough air be sent to the rooms to provide ventilation. If this amount is less than that needed as a heat carrier, all well and good, the first amount will be used, but if it should be greater, then the first amount will need to be increased arbitrarily to agree. This increased volume will then be used instead of that calculated as a heat carrier only. As previously stated, the cubic feet of air per hour as a ventilator

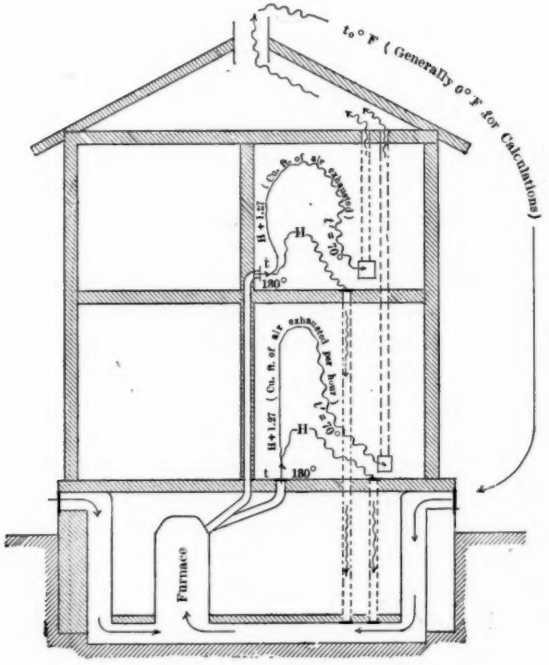


FIG. 2.

may be taken as 1,800 N where N is the number of persons to be provided for.

9. In Fig. 2, let t = temperature of the air entering the room from the register, say, 130 degrees F.; t' = temperature of room, say, 70 degrees, and t_0 = temperature of outside air, say, 0 degrees. Let, also, H = heat loss from the room in B. T. U. per hour as calculated by formula. There is, of course,

a certain loss of heat expected in any case by the air leakage. This is included in the value H, but by the B. T. U. carried away by the exhausted air is meant where special provision is made for venting to the outside air. The heat loss H will be the same for all methods of heating, and should be carefully worked out for the various rooms by the use of some well-tried formula, because all the other calculations in the system are based upon it. It will be seen that the heat given off as the air drops in temperature from t to t' must equal the heat loss H. The safe temperature of the air as it leaves the register is 130 degrees F. This may at times reach 140 degrees F., but it is well to use the lower value for the calculations. If, as is usually the case, the room air is 70 degrees F., the incoming air will drop in temperature through 60 degrees F., and will give off $60 \div 55 = 1.09$, say, 1.1 B. T. U. per cubic foot. Since, in the design of any plant, H is the first thing to find, we will assume this value as having been obtained by some satisfactory formula, and we will base all the following results upon it. Having determined H, then the amount of air needed as a heat carrier measured at the register is

$$Q = \frac{55\,H}{t - t'} = \frac{H}{1.1} \text{ approx.} \ldots\ldots\ldots\ldots\ldots\ldots (2)$$

where 55 cubic feet of air may be heated from 59 to 60 degrees F. by one B. T. U. This is proven as follows: The specific heat of air at 32 degrees F. is 0.238, then one B. T. U. will raise $\frac{1}{0.238} = 4.2$ pounds of air from 32 to 33 degrees, and if one cubic foot of air at 32 degrees weighs 0.0807 pound, we have $\frac{4.2}{0.0807} = 52$ cubic feet of air at 32 degrees, or $52 \times \frac{520}{492} = 55$ cubic feet of air from 59 to 60 degrees F.

10. Formula 2 gives the required amount of air to carry the heat for ordinary building losses. This amount of air at the register will be practically constant for the chosen temperatures, no matter if the air be taken back to the furnace, i.e., recirculated, or be vented to the air and fresh air taken in to fill its place. The only part of the plant that would be affected by this change from inside to outside air would be the size and capacity of the furnace.

11. Is this Amount of Air Sufficient for Ventilation if Taken from the Outside?—Take the 13 × 15 × 10 foot sitting-room, Plate 2. Let the estimated heat loss be 14,000 B. T. U. per hour, then $Q = 12{,}727$ cubic feet. With a room volume of 1,950 cubic feet, the air will change 6.5 times per hour, and, allowing 1,800 cubic feet of air per person, will supply seven people with good ventilation, if fresh air be used. Stated as a formula, this would be,

$$N = \frac{H}{1.1 \times 1800} = \frac{H}{2000} \text{ approx.} \quad \ldots\ldots\ldots\ldots (3)$$

As a matter of fact, ventilation for half this number would be ample in an ordinary residence room excepting on extraordinary occasions. So it would seem that the subject of ventilating air will be more than taken care of if the ducts are planned to carry air for heating purposes only.

12. If for any reason Q is not sufficient for ventilation, then more air must be sent to the room and the temperature dropped correspondingly to avoid overheating the room. Let Q_v = total volume of air per hour, including extra air for ventilation, measured at the register, and t_v = temperature of the air at the register, then,

$$t_v = 70 + (55\,H \div Q_v) \quad \ldots\ldots\ldots\ldots\ldots (4)$$

13. Heat Lost by Ventilation.—Now, if this air, which we call a heat carrier, is not allowed to escape from the building through vent ducts, but is taken back to the furnace and recirculated, the only loss of heat will be that calculated by the formula. As a matter of fact, the air thus used would soon become contaminated and unfit for the occupants to breathe; hence, it is customary to exhaust through vent flues a part or all of the air sent from the furnace. All the air exhausted carries away an additional loss of heat from the building in proportion to the drop in degrees from 70 to that of the outside air. Take, for example, a room under three different conditions of service on a zero day: First, when all the air is recirculated; second, when only enough air is exhausted to give good ventilation; third, when all the air is exhausted.

Under the first case, the loss will be the same as that calculated by the formula—i.e., $= H$.

The second, assuming N people to need ventilation, will be,

$$H' = H = [(1800 \times N \times 70) + 55] \ldots\ldots\ldots\ldots\ldots\ldots (5)$$

The third will be

$$H'' = [(t - t_0)\, H] \div (t - t') \ldots\ldots\ldots\ldots\ldots (6)$$

Formula (5) is a general formula, and will fit any condition and any degree of purity in ventilation. With $N = 2$, this would come near to average practice in the operation of furnace systems. Formula (6) is only true where the volume Q is circulated. If larger volumes are circulated use (5).

Little thought need be given, therefore, to the subject of ventilation in the average residence further than to plan for the entering of the fresh air to the furnace, and its withdrawal through vent ducts to the attic. Since the quantity of air is sufficient, the owner may regulate to suit his needs.

14. Both lines of air entering the furnace should be dampered. Concerning the best point from which to return the room air, nothing very definite can be stated. It is best taken from the coldest part of the house, generally near a door.

15. Moisture in Air.—Moisture in the air is a benefit both to the heating and the ventilating systems in any room. With moist air in the room, a person may feel comfortable when the temperature is several degrees lower than the comfortable temperature of dry air. Dry air absorbs the moisture from the skin. The vaporization of this moisture causes a loss of heat from the body, and gives to the person a sense of cold, which is only relieved when the temperature of the room is increased. Air that is fairly saturated with moisture will not permit of much evaporation from the skin, because there is not much demand for this moisture in the air, consequently, the body retains that heat and the person has a sensation of warmth which is only relieved by lowering the temperature of the air in the room. On the other hand, at low temperature, the moisture in the air chills the surface of the skin by convection, a condition that is not so noticeable when the air is dry. It follows from the above statement that the range of comfortable temperatures is less for moist air than for dry air.

16. Concerning the effect of moisture in the air in its relation to the heating and ventilating of the room; dry air does

not absorb radiant heat; moisture in the air has this quality. It has also somewhat less weight than dry air and is more buoyant. Because of the possibility of storing up the radiant heat within the particles of moisture, and because of its convection qualities, it serves as a good heat carrier for the heating system.

17. HUMIDITY OF THE AIR.—The *actual humidity* of the air is the amount of moisture in the air at any temperature. The *relative humidity* is the amount of moisture actually in the air divided by the amount of moisture which the same volume of air could hold at the same temperature when saturated. It is very important that the heating engineer be able to add to or to take away from the amount of moisture in the air supply of any building. To find the amount of moisture that should be added or subtracted in any case, it is first necessary to determine the humidity of the air at various points along its course. This may be obtained by the aid of the wet-and-dry-bulb thermometer, or by any one of a number of hygrometers supplied by the trade.

18. THE THEORETICAL AMOUNT OF MOISTURE TO BE ADDED TO AIR SO AS TO MAINTAIN A CERTAIN HUMIDITY.—Warm air has a much greater capacity for holding moisture than cold air. When air is taken at a given outside temperature and heated for interior service, the volume increases with the absolute temperature and the humidity decreases rapidly. Air thus treated becomes dry and unpleasant to the occupant, as well as being detrimental to the furnishings of the room. Some means should, therefore, be provided to supply this moisture to the air current.

19. In calculating the amount to be added, let Q = volume of air in cubic feet per hour entering the room at the register; t = temperature in degrees F., and T = its absolute temperature; let Q' and Q_0 = the corresponding volumes of air in the room and on the outside, with t' and t_0 their temperatures in degrees F., and T' and T_0 = their absolute temperature; also, let h' and h_0 be the humidities, respectively, of the room air and the outside air. Then, from the formulas,

$$TQ' = T'Q \text{ and } TQ_0 = T_0Q \quad \ldots\ldots\ldots\ldots (7)$$

find Q' and Q_0.

20. From prepared tables find the amounts of moisture M' and M_0 in one cubic foot of saturated air at the temperatures t' and t_0; multiply these by the respective humidities and volumes, and the difference between the two final quantities will be the amount of moisture required per hour as expressed by the formula,

$$W = Q' M' h' - Q_0 M_0 h_0 \ldots\ldots\ldots\ldots (8)$$

21. APPLICATION.—Let $Q = 5000$, $t = 130$, $t' = 70$, $t_0 = 30$, $h' = .50$, $h_0 = .50$, $M' = 7.98$, and $M_0 = 1.958$, then

$$Q' = (5000 \times 530) \div 590 = 4500.$$
$$Q_0 = (5000 \times 490) \div 590 = 4150.$$
$$W = 13{,}890 \text{ grains, or } 1.984 \text{ pounds per hour.}$$

This means that approximately 2 pounds of water would be evaporated for every 5,000 cubic feet of fresh air entering the register.

22. The practical difficulties experienced in attempting to moisten air that is being raised to a higher temperature are great. When a current of air passes over the surface of still water, as is the case with moistening pans, it takes up very little of the water vapor unless both the air and the water are at a fairly high temperature. If the water is in motion, as produced by a spray or a drip, then the air will take up large quantities of the moisture, but much of it will be merely suspended in the air in a very finely divided state and will be deposited on the first cool object it comes in contact with. Such moisture cannot properly be said to be *in* the air.

23. HEAT REGISTERS.—The velocity of the air as it leaves the register is best taken between three and four feet per second to insure against unpleasant drafts in the room. This is especially true for registers located near the floor line. Assuming the mean figure 3.5 feet per second, we have,

$$\text{Area of Net Heat Register} = 55\,H \times 144 \div (60 \times 3.5 \times 3600)$$
$$= 0.01\,H \text{ square inch, approx.} \ldots\ldots (9)$$

The *nominal size* or the *catalogue size* of the register is about,

$$\text{Gross heat register} = 1.5 \times \text{net heat register} \ldots\ldots\ldots (10)$$

Floor registers are best adapted to halls and rooms on the

first floor. There is a serious objection to their use, however, when they require the cutting of carpets or hardwood floors. This restricts their use very much. For rooms on the second floor the wall register is preferred. Floor registers on the first floor may safely be placed on the more exposed sides of a room when this can be done without making the leaders too long. Wall registers should always be in the inner walls.

24. HEAT STACK.—To get the proper size of the stacks in any heating system is a very important part of the design of that system. By some designers the cross-sectional area is taken roughly as a certain ratio to that of the net register. This has been quoted anywhere from 50 to 90 per cent. Such wide variations between extremes of air velocity should certainly receive careful application. Professor Carpenter suggests 4, 5 and 6 ft. per second, respectively, as the air velocity for first, second and third floors. J. P. Bird, in *The Metal Worker* of December 16, 1905, used 280, 400 and 500 ft. per minute, which is approximately 4.5, 6.5 and 8 ft. per second under like conditions. From the basis of the net register (figured at 3.5 ft. per second) the two quotations above give stack values approximately as follows: First floor, 80 to 88 per cent. of the net register; second floor, 55 to 70 per cent, and the third floor, 44 to 60 per cent. In any case, the formula for the area of the stack is developed in the same way as the net register by substituting the approved air velocity in the place of 3.5.

25. The air velocity in the stack is based upon the formula $V = \sqrt{2gh}$, where h = (effective height of stack) $\times$ $(t - t') \div (460 + t')$. V is in feet per second; t is the temperature of the stack air and t' is the temperature of the room air. The calculated results from this formula are much higher than obtain in practice because of the shape of cross sections of the stack, the friction of its sides and the abrupt turns in it. Stack areas may be safely taken as follows:

$$\left.\begin{array}{l}\text{First floor, S. A. (sq. in.) } 0.007\ H \\ \text{Second floor, S. A. (sq. in.) } 0.006\ H \\ \text{Third floor, S. A. (sq. in.) } 0.005\ H\end{array}\right\} \ldots\ldots\ldots (11)$$

26. Good-sized stacks are always advisable, but because of the limited space between the studding it becomes necessary

at times to put in a stack that is too small for the room or to increase the thickness of the wall. *Most second-floor stacks are too small* to heat the rooms properly. The shape is also against maximum efficiency. Round sections are best, but these are difficult to place. Deep rectangular sections, such as 5½ inches by 13½ inches, work well; but the shallow sections that fit in a 4-inch studded wall should be applied to only the smallest rooms.

27. Results from different installations show that there is a variation in the practice of proportioning stacks, as commonly installed, of 50 per cent. or more. This is not so noticeable in the first-floor rooms when stacks are used as it is in those of the second floor. Some of this difference is no doubt due to the fact that the thickness of the walls has been previously determined by the architect, and since the heating system was probably a secondary consideration, no party would take the initiative in changing the sizes. In many cases, too, the owner is indifferent or possibly advocates small stacks because of the use to which the room is to be put, *i.e.*, less heat for sleeping rooms, etc., etc. A good rule, and an old one, is to heat every room as though it were to be a living room in the coldest weather, and then let the owner regulate to suit his needs, even to a complete closure of the duct. Where thin partition walls are put in, say, 4-inch studding set 16-inch centres, and not enough space is allowed for a single stack, two stacks may be put in. This is somewhat more expensive, but it is very satisfactory, since it gives a better distribution of heat in the room, and when all the heat is not needed, as in mild weather, one line may be shut off entirely. A better way is for the architect to anticipate this state of affairs and specify walls of sufficient size. The ideal conditions will be reached when the architect actually provides air shafts of sufficient size to accommodate either a round or a nearly square stack. When this time comes, a great many of the furnace-heating difficulties will have been solved. This point has many times been well shown where furnace systems have been installed in old houses. Large rectangular shafts or stacks were run up the corners of first-floor rooms to reach second-floor rooms. These second-floor rooms always had heat to spare. Stacks placed in this way and finished over to suit the finish of the rooms are not very unsightly; and how much better, still, were they planned by

the architect and properly enclosed so as to harmonize in the general layout of the room!

28. All stacks should be located in inside or partition walls and, if possible, should look toward an outside or cold side of the rooms. This protects the air current from excessive loss of heat, as would be the case in an outside wall. It also provides more uniform distribution of air. Two rooms should not be taken from the same stack, but two stacks may run to the same room and may be taken from the same leader.

29. VENT REGISTERS AND STACKS.—It is well to install vent registers and stacks in the inner walls leading to a general vent in the attic. If all the air were to pass out of the vent register at the same velocity as it entered through the heat register, the area of the vent register would be to the area of the heat register as the ratio of the absolute temperatures of the leaving and entering air. With $t' = 70$ and $t = 130$, we have theoretically

$$\text{Net vent register} = (530 \div 590 = 0.9) \text{ net heat register.}$$

As a matter of fact, however, some of the air leaves through other openings, and the vent registers need not be so large. The following will be found satisfactory:

$$\text{Area vent register} = 0.8 \text{ area heat register} \quad \ldots\ldots (12)$$

also,

$$\text{Area vent stack} = 0.8 \text{ area heat stack} \quad \ldots\ldots\ldots\ldots (13)$$

30. LEADER PIPES.—Since all the air that passes through the stacks must pass through the leader pipes, it would at first seem reasonable to assume that the areas of the two would be equal. It must be remembered, however, that the stacks, because of their vertical position, have less friction than the nearly horizontal leader pipes, and will consequently retard the air less. There will also be some loss of heat in the air as it passes through the leader pipes, consequently, the volume of air entering the leader from the furnace will be greater than that going up the stack. It would be well from the above reasons to make,

$$\text{Area of leader pipe} = (1.1 \text{ to } 1.2) \text{ stack area} \quad \ldots\ldots (14)$$

the exact figures to depend upon the length and inclination of the leader and the selection of the diameter of the pipe. All

leaders should be round and should be free from unnecessary turns. They should be given a good upward pitch toward the stack, and should be covered to avoid heat loss and to provide safety to the plant. The connection between the leader and the stack should be by a long radius bend, and should not head into the stack at right angles.

31. Cold Air Duct.—The area of the cold air duct is determined largely by experience, as in the case of the vent register. It may be,

$$\text{Area cold air duct} = 0.8 \text{ total area of leaders} \quad (15)$$

32. Assume the average velocity of the air in the leaders to be 6 feet per second, and the area of the cold air duct to be as shown above, then if the air in each were of the same temperature, the velocity in the cold air duct would be $6 \div 0.8 = 7.5$ feet per second, but since the temperatures are different, the velocities will be in proportion to the absolute temperatures. Hence, it is at 0° F., $0.78 \times 7.5 = 5.8$; at 25° F., $0.82 \times 7.5 = 6.2$ and at 50° F., $0.88 \times 7.5 = 6.6$ feet per second. It is seen by this that although the area of the cold air duct is contracted to 80 per cent. of that of the leaders, yet the velocity in all cases is below that of the leaders.

33. It is always well to have a cold air duct that is large in cross sectional area and free from obstructions and sharp turns. The air should be taken from a point on the outside as high above ground as convenient, and this opening should be vertical and well screened. The inside ducts should be tight, and should have no drainage water or refuse collecting in it. If an inside return circulation be added, both lines may unite near the furnace, and each line should be valved. If it is decided that there never will be a time when all the air Q need be taken from the outside, then the area of the cold air duct may be reduced a certain amount. This is not a very safe policy, and should be done only when conditions seem to demand it.

34. The Recirculating Duct and Register will be proportioned to the cold air line to suit each individual case. The best size, of course, is that of the cold air line.

35. The Furnace.—A good way to select the furnace size is by grate area, and this is estimated from the total heat loss from the building, figured on the basis of a certain degree of

ventilation. In obtaining the grate area, it is necessary to assume the quality of the coal, the efficiency of the furnace and the pounds of coal burned per hour per square foot of grate. The quality of the coal selected would be between 13,000 and 14,000 B. T. U. per pound, the efficiency of the average furnace is about 60 per cent., and the coal burned per square foot of grate per hour ranges from 3 to 7 pounds. Concerning the last point, there may be a wide difference of opinion. Higher temperatures in the combustion chamber are conducive to economy, hence to reduce the size of the firepot and the combustion chamber and firelight, and often would seem to be the ideal way. On the other hand, with high temperatures in the combustion chamber, the loss up the chimney is increased. Probably the one factor which is most effective in settling this point is the inconvenience of frequent firing. Furnaces are charged from two to four times every twenty-four hours. This requires a good-sized firepot and a possibility of banking fires. To allow 5 pounds per hour is probably as good an average as can be made for most coals in furnace work.

36. APPLICATION.—In our ten-room residence, here shown, the heat loss H on a zero day by formula is, say, 100,000 B. T. U. per hour. This will give $Q = 90{,}909$ cubic feet per hour as a heat carrier. Assuming as a maximum that 10 people will be in the house, and that they will need 18,000 cubic feet of fresh air per hour for ventilation, this air will carry away approximately 22,900 B. T. U. per hour, making a total heat loss from the building of 122,900 B. T. U. per hour. Now, if the furnace is 60 per cent. efficient, and it burns 5 pounds of 14,000 B. T. U. coal per hour per square foot of grate, we will have the area of the grate $= 122{,}900 \times 144 \div (0.60 \times 14{,}000 \times 5)$ $= 421$ square inches. This gives a grate 23.2 inches in diameter.

37. With coal at 13,000 B. T. U. per pound, the grate would be 454 square inches, or 24 inches in diameter. In either case, a 24-inch grate would be selected. With the assumptions as made above, the formula becomes G. A. $=$ $0.0035\ H$ for the better grade of coal, and G. A. $= 0.0037\ H$ for the poorer grade of coal, from which the following may be taken:

Grate area in square inches $= 0.0036\ H$ . . . . . (16)

This value may be checked with the catalogue rating, which is

usually given in capacity of room space the furnace will heat. The proposition of selecting a furnace will be much simplified when the committee on standards succeeds in lining the manufacturers up to a standard code regarding heating surface, grate surface, wind area and the like.

38. APPLICATION OF THE ABOVE FORMULAS TO A TEN-ROOM RESIDENCE.—In every design the calculations should be made complete and tabulated for easy reference and comparison. These tabulations then should be kept for future reference. The table on page 154 is a complete summary of the calculations for the furnace design shown in Plates I, II and III, the heat losses H being figured by the "Carpenter formula."

DISCUSSION.

Professor Carpenter: I have felt for a long time that our systems of furnace heating were really more important than the systems of steam heating and hot water heating. Where air does not have to be carried a long distance horizontally there is no system more certain in its results or more healthful.

Mr. Chew: I am glad to hear Professor Carpenter say that at this time. As the result of facts presented to this Society a general movement is in progress in the United States to uplift the furnace heating business, and at the time this movement took form in the National League, the question was pointed out that the styles of risers used in partition walls more than anything else brought this system into disrepute. The people should join with them in a movement to get architects and builders to see that sufficient depth is given to warm air flues to allow an unimpeded flow.

Mr. Seward: In regard to the capacity of hot air furnace being determined by the grate area and coal consumption, I think that is entirely correct. I call your attention to the fact that in the ratings of furnaces adopted by some manufacturers this method is used and the rating is expressed in equivalent cubic feet of air as determined by the requirements of all the rooms in the building to be heated. I believe this method is going to be endorsed by other manufacturers.

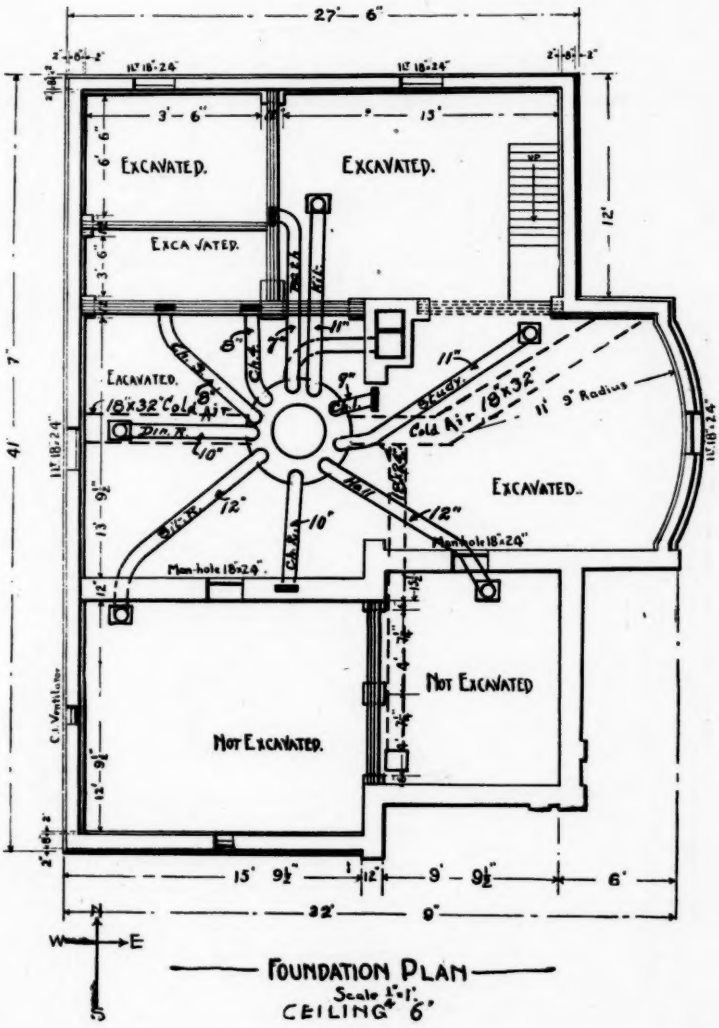
TABLE.

Formula $\left(G+\frac{W}{4}+0.02nC.\right)70 = H.$

Room.	G.	0.25 (W—G).	0.02nC.	N.	H.	Q.	Area Net Heat Reg.	Heat Reg. Size.	Area Heat Stack.	Area Leader.	Area Net Vent. Reg.	Vent. Reg. Size.	Area Vent. Stack.	Remarks.
Sitting room	38	85	78	2	14,000	12,727	140	14×16	.....	100	112	12×14	67	Allow for cold floor.
Dining room	28	28	84	2	10,800	9,818	108	12×14	.....	77	86	10×12	52	" 10 per cent. for closet and exposure.
Study	42	52	78	2	13,250	12,045	132	14×16	.....	94	106	12×14	64	" " " " " exposure.
Kitchen	28	65	55	2	11,900	10,818	119	12×14	.....	85	95	12×12	60	" 15 " " " pantry, stair and exposure.
Reception hall	29	73	104	3	14,000	12,727	140	14×16	.....	100	112	12×14	67	" for floor and hall well on second floor.
Chamber 1	42	45	35	1	9,400	8,544	94	12×12	61	67	75	10×12	45	" 10 per cent. for exposure.
Chamber 2	38	60	36	1	9,850	9,854	98	12×12	64	70	78	10×12	48	" 5 " " " south closet.
Chamber 3	28	26	31	1	6,600	6,000	66	9×12	43	47	53	8×10	32	" 10 " " " closet and exposure.
Chamber 4	28	30	22	1	5,600	5,091	56	8×10	36	40	45	8×10	27	Add closet to room.
Bath	14	17	26	2	4,400	4,000	44	8×10	28	31	35	8×8	22	Allow 10 per cent. for closet and exposure.
Totals	315	481	.....	....	99,800	.....	.....	.....	.....	711	.....	.....	.....	

Diameter of grate allowing ventilation for ten people = 24 inches. Cold air duct = 569 square inches = 18×32 inches.

In selecting the various stacks and leaders it would be well to standardize as much as possible and avoid the extra expense of installing so many sizes. This can be done if the net area is not sacrificed.



FOUNDATION PLAN
Scale 1"=1'.
CEILING 6'.

PLATE I.

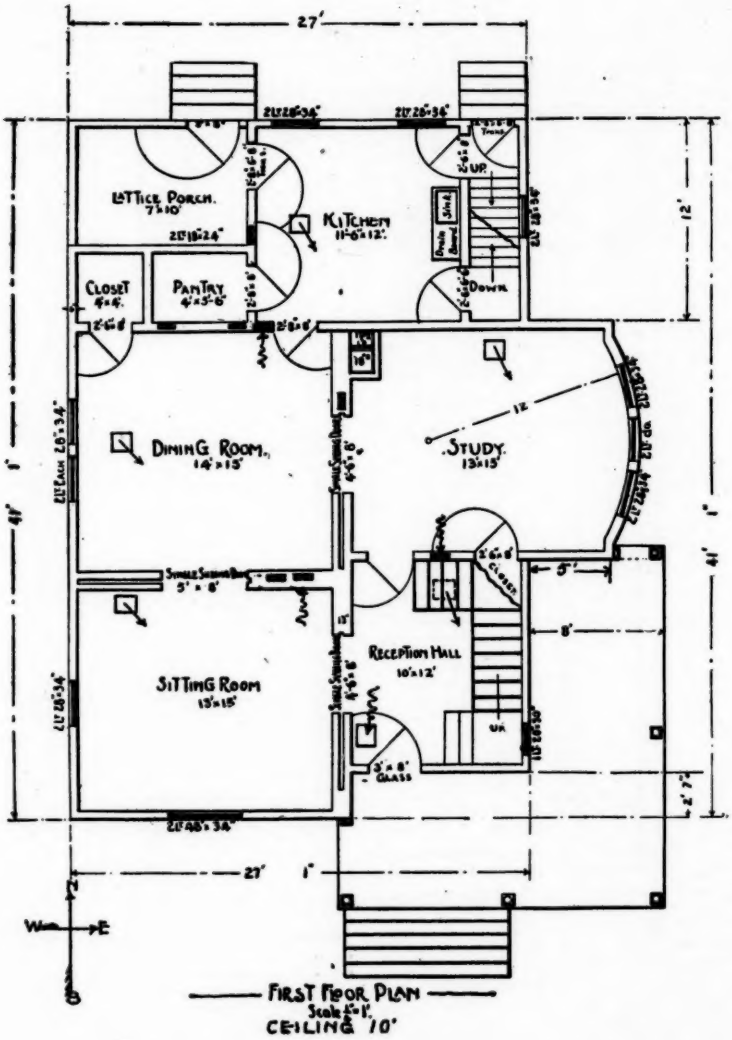
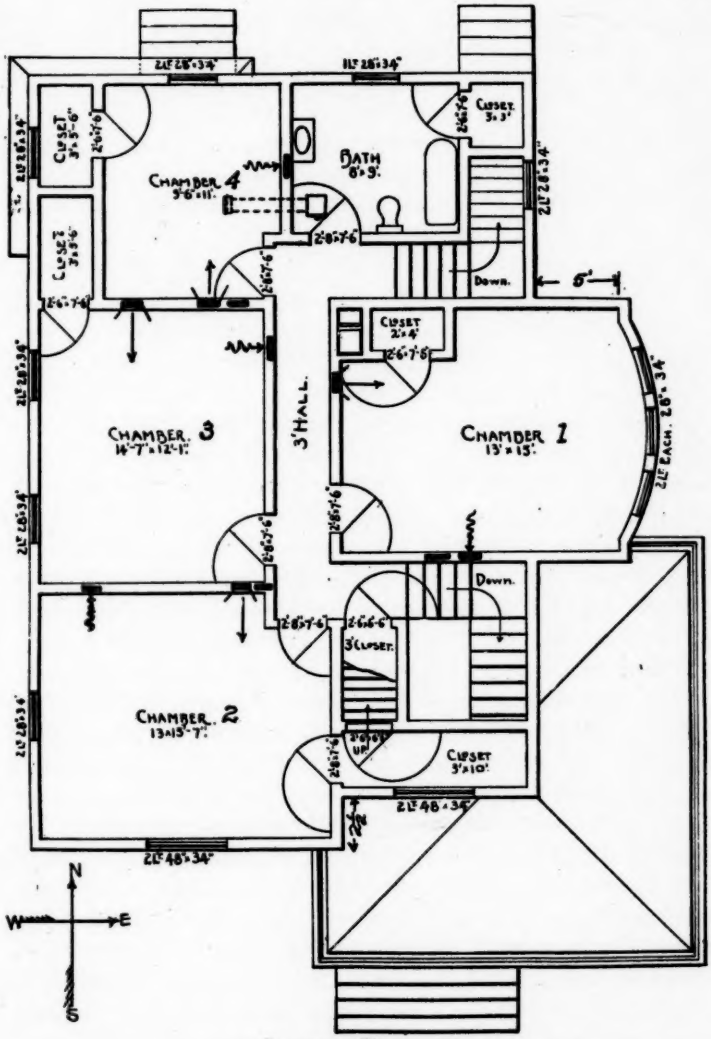

27'
LATTICE PORCH.
7'x10'
KITCHEN
11'-6"x12'
UP.
DOWN
CLOSET
4'x4'
PANTRY
4'x5'-6"
DINING ROOM.
14'x15'
STUDY.
13'x15'
SITTING ROOM
13'x15'
RECEPTION HALL
10'x12'
GLASS
27'
W
E
FIRST FLOOR PLAN
Scale 1/4" = 1'
CEILING 10'

PLATE II.



SECOND FLOOR PLAN
Scale. ¼"-1'.
CEILING 9'

PLATE III.

CC.

THE EFFECT OF WIND ON HEATING AND VENTILATING.

BY H. W. WHITTEN.

(Associate Member of the Society.)

For some years the writer has been a close observer of the action of wind on modern types of buildings as affecting heating and ventilating. The problem confronting the engineer in modern heating is to provide sufficient heat and air change in any weather condition liable to occur. It is clear that if there are conditions in the building that are liable to be greatly affected by wind variation, that he must estimate their effect on the interior of the building. The most vulnerable places for the wind to exert its varying influence are the windows. These are usually made of the sliding type, and, in order to be readily movable in all seasons, must have at least 1/16 inch clearance all round. This clearance is usually greater. The inward or outward movement of air through these crevices is practically unimpeded and is nearly proportionate to outside conditions. Tests made with a fan forcing air against a sash show that a pressure equal to a wind movement of fifteen miles per hour will force about 185 cubic feet of air through one lineal foot of sash crevice 1/16 inch in width in one hour. Tests taken on sash in the open show that an average of 146 cubic feet per lineal foot per hour comes through the same space when an actual wind of fifteen miles per hour prevails.

The effect of this air leakage was tested on a steam radiator, but because of the variation of interior conditions of the radiator due to the fact that the pressure varied at times, that the steam was sometimes wet and at other times dry, and that

more or less air mixed with the circulation, an electric radiator was substituted. The heat from this radiator was fairly constant and could be readily checked. The action of air leakage on this radiator was readily apparent. A testing house was constructed, in which the walls were practically proof against heat loss. A window was placed in one side, which could easily be replaced by others of different clearance or with ones provided with wind-stopping devices. This house could be rotated so as to face prevailing winds.

These wind velocities and outside temperatures were recorded, also the time required to raise the interior temperature by means of the electric radiator a certain number of degrees. The current being shut off, time observed during which the temperature fell to starting point. This operation was repeated until the walls practically ceased to absorb heat. The sash was then changed for others of different clearance, which were subjected to the same test. Sash with insulating devices were also tested. These tests conclusively demonstrated that the average ratio of heat loss by leakage as the wind increased was, in the case of a sash with 1/16 inch clearance, 25 per cent. per mile, or for four miles increase in wind velocity the leakage heat loss increased 100 per cent. In the case of the insulated sash the leakage heat loss increased at the average rate of 5 per cent. per mile of wind movement.

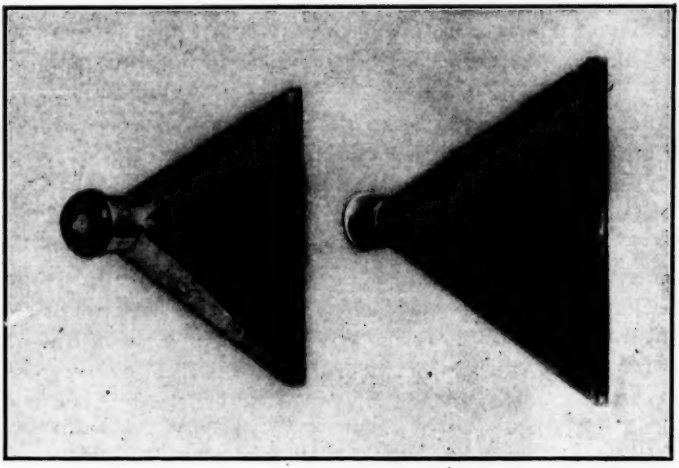
The actual comparative leakage heat loss between a sash with 1/16-inch clearance and the insulated sash, with a difference of 44 degrees of temperature during a 15-mile wind, was as 5 to 1. The comparative cubic leakage being as 9 to 1.

The average wind movement in localities where heating is important is about thirteen miles per hour during the heating season.

Increasing velocity of wind tended to decrease the rate of progression of loss and leakage, presumably because the pressure of the wind held the sash more tightly against the stops while its effect on the glass itself continued. It was evident from the investigations thus far pursued that, if windows were properly insulated, the radiation calculated against this heat loss from inleakage could be practically eliminated, and the writer has followed this practice successfully on the basis of the prevention of inleakage. In further looking into this sub-

ject, however, another and still more important phase of the effect of wind has appeared.

In order to test quickly the wind leakage in various buildings, particularly those where a dispute as to the efficacy of the apparatus occurred, an instrument was designed for the purpose of measuring leakage through any section of window joint, taking in about two lineal feet. The accompanying cut



shows its construction. A 4-inch anemometer placed in the nozzle showed the air movement. Very many tests have been taken with this instrument, and have shown uniformly that the outflow from window crevices on the leeward sides of buildings exceeds the inflow from the windward sides. Especially is this true in the case of buildings heated by the indirect method with forced circulation. The expanded warmed air in the rooms on the windward sides of the building exerts a repelling force against inleakage, and is sufficient to overcome that caused by moderate winds of three to four miles per hour. Above this velocity inleakage occurs, increasing with the outer wind movement. This inleakage is met by the warmed air inflow, mainly in the upper portion of the room, and mixes with it to some degree. The greater portion falls by natural gravity to the floor and causes cold currents rising in spurts

wherever it meets a warm human body, but the bulk of it is added to the vent flow. It has in the meantime upset the *calculated* circulation from the inlet to the vent. In cases of this kind the thermometer will frequently register 70 degrees on the wall and 58 degrees on the floor. Direct radiation placed under the windows is a frequent makeshift to remedy this situation. The conditions on the leeward sides are worse from either a heating or ventilating standpoint.

Not being opposed by wind pressure, the expanded air will escape by its most natural channel, i.e. the window crevice. It is usually introduced near the upper part of the room, and is *expected* to escape by means of the vent near the floor. Experiments have shown that the addition to the flow of the vent on the windward side from inleakage is much less than the subtraction from the flow of the vent on the leeward side caused by outleakage. In these cases the rooms were partitioned and a hall intervened.

The action of the wind blowing around and over the building is the undoubted cause of this acceleration of the outleakage. As it sweeps by, an area of low pressure is formed in the lee of the sheltered side. This area exerts a siphonic action on every crevice in the sheltered side of the building, and is a continuous air pump on the interior supply of heat units. As most of these crevices are above the normal breathing level, the loss from them is absolute. In a school building, recently examined by the writer in Pittsburgh, it was found that the aggregate free opening around 150 windows averaging four feet 6 inches in width by 7 feet in height was approximately 46 square feet, or about 44 square inches per window. The required 30 cubic feet of air per minute, even when supplied at a temperature of 120 degrees, failed to warm this building during moderate winter weather.

The results of a series of tests taken recently in the tower of the Public Building, Philadelphia, are as follows: Average outside temperature, 38 degrees. Inside temperature, 70 degrees.

Instrument shown in cut used with an anemometer 4 inches in diameter. Average sash clearance 1/16 inch.

Lineal inches of crevice covered by the instrument 24.

Area of crevice		1.5 inches.
" " anemometer		12 "
Rate of outside wind		1,020 feet per minute.
" " inleakage		125 " " "
" " outleakage		146 " " "
" " outside wind		975 " " "
" " inleakage		90 " " "
" " outleakage		109 " " "
" " outside wind		1,240 " " "
" " inleakage		119 " " "
" " outleakage		141 " " "
" " outside wind		1,420 " " "
" " inleakage		140 " " "
" " outleakage		158 " " "
" " outside wind		1,350 " " "
" " inleakage		132 " " "
" " outleakage		149 " " "

A comparison of these figures shows that the average outleakage is from 15 to 20 per cent. greater than the inleakage.

I have found that the average rate of inleakage in many buildings tested was about 10 per cent. less than that shown in the testing-house experiments and that the rate of outleakage was about 10 per cent. greater.

This is probably due to the fact that the cubic contents of the testing house (about 78 cubic feet), as compared with the lineal feet of window crevice in it (14 feet), was less than average room conditions. A room with 16 feet exposed wall, 12 feet deep, with two windows 6 feet high by 3 feet wide, would be nearly typical. Such a room would contain 1,920 cubic feet and have 42 lineal feet of window crevice. In the testing house the proportion of window crevice to cubic contents is 1 to 55. In the typical room mentioned it is approximately 1 to 46.

The effect of this greater volume of expanded air would be to retard the inleakage. Contrariwise, it would tend to accelerate the outleakage, which is also influenced by the suction from the area of low pressure existing on the sheltered sides of the building.

The writer had, previous to these tests, used, with good results, the formula published by Prof. John R. Allen. This formula is as follows

$$\left(\frac{W}{4} + G\right) d\, n$$

W = square feet exposed wall.
G = square feet glass surface.
d = difference between inside and outside temperature.
n = leakage and wall filtration.

In this formula $n = 1.5$ to 2, according to conditions of wall construction, fitting of windows, etc.

With windows properly insulated, this formula may be modified as follows:

$$\left(\frac{W}{4} d\, n\right) + \left(G\, d\, n_1\right) \text{ in which } n_1 = 1.1.$$

This formula, while to some degree empirical, is more logical than any now in use which contain a variable factor for leakage. With window insulation the interior condition becomes stable and the maximum loss in any wind known. Artificial circulation is not interfered with or upset, and the control of inward or outward currents is established.

DISCUSSION.

Mr. Kinealy: I would like Mr. Whitten to tell us how many cubic feet of air will leak per lineal foot per hour. If we know that, and we assume the temperature outside is zero and the temperature inside 70 degrees, we can at once calculate how many heat units will have to be supplied to compensate for that leakage. When we can do that we are in a position to calculate exactly the loss.

Mr. Donnelly: I wish to take exceptions to what Professor Kinealy has said. As to leakage through brick walls, if any of the gentlemen with us have had an opportunity to test that I would like to have some figures on it. If you take about ten feet of surface of ordinary brick wall you will find considerable leakage from wind pressure right through the brick work, through the bricks themselves. I do not think any brick tests have been made. In addition to the leakage through the cracks of window casings and window construction we have this other leakage which comes directly through the walls of the buildings, and as there is a great deal larger number of square feet of walls than windows, the loss of air through the walls will amount to fully as much as through the crevices of the windows.

Mr. Whitten: I will say for the benefit of Professor Kinealy that a series of tests were conducted in Detroit about a year and

a half ago under the supervision of some noted engineers, including Professor Allen, these tests being made where the air was forced against various sashes with various clearances. That was embodied in an article written by B. S. Harrison, and published in the *Heating and Ventilating Magazine* in November, 1907, and another written by myself the following month of 1907, and was distributed to the members of the Society. I think that in my paper I state that an average of 146 cubic feet per hour per foot of sash joint will come through providing the air has some means of egress after it gets in, a foot of sash joint being 1/16 in. wide. The result of the building tests shows 185 cubic feet, and the difference is undoubtedly due to the recoil or splash effect of the wind in striking an obstruction.

President Mackay: Have you any data on the question raised by Mr. Donnelly on the filtration of air through walls?

Mr. Whitten: I haven't anything that would be definite.

Professor Kinealy: Nearly ten years ago, I think, I did some work for the *Metal Worker,* and as a result of the experiments that I made on the leakage of air through windows I devised a formula which was published by them in their journal. As I understand, Mr. Whitten says that for every lineal foot of sash crack we may expect about 146 cubic feet of air to leak through per hour. Now 146 cubic feet of air will require about 3 heat units to raise its temperature one degree, that is, one heat unit will raise 50 to 55 cubic feet of air one degree, and to raise the temperature of this air from zero—assuming it enters the room at zero—to 70 will take 70 times 3, or something like 210 heat units. As the result of my investigation I said that we must, for the average window to compensate for leakage, have one-fifth square foot of direct radiation surface for every lineal foot of window crack. That is less than Mr. Whitten gives.

Then I devised a formula in this way: It is not always possible to determine the exact number of lineal feet of crack surface, but windows are so shaped that the lineal feet of crack surface is very nearly equal to five times the square root of the area of the window. A window 3 ft. wide and 8 ft. high will have two cracks each 8 ft. long and 3 cracks each 3 ft. long, making altogether 25 lineal feet. The area of this window is 3 x 8, or 24 square feet, and the square root of 24 is nearly

5, so that we have pretty nearly five times the square root of the area. On that basis I figured a rule something like this:

$$\text{Radiation for window} = \sqrt{s}$$

s is the area of the window in square feet.

In old buildings I added about 50 per cent., sometimes 10 and sometimes 25.

President Mackay: That certainly is valuable information.

A Member: Is that the area for one window or the area for total glass?

Professor Kinealy: Each window considered separate by itself. That means this: One window having an area of 24 square feet would require 5 square feet of ordinary radiation surface for leakage. Two windows having an area each of 24 square feet would require 10 square feet for leakage. One window having an area of 48 square feet would require only 7 square feet for leakage. That is why it is that hot houses where you have a large amount of glass surface will not lose as much heat per unit of area of glass as windows. It is very common to figure glass surface in hot houses at a smaller rate of transmission than you figure windows. That is due entirely to leakage in the windows from cracks. In estimating the requirements to heat a room we should take into account each window by itself. Figure out each window and multiply the result by the number of windows of that particular size. That rule was published in the *Metal Worker* eight or ten years ago.

Mr. Munroe: The subject at hand is one which Mr. Whitten has given considerable thought and attention to, and is deserving of our careful consideration. It applies particularly to apartment houses, residences, and hotels. It is not so serious, however, when we consider the facts. And, again, it is somewhat in opposition to the subject that was discussed thoroughly this morning; viz., ventilation of factories and school buildings. Air leakage is an advantage where a number of people occupy a room, as in the case of a factory or school building, provided there has not been a ventilating system installed. I know from experience with a particular apartment house in Baltimore City where due appreciation of air leakage had been taken cognizance of at the time the design was made.

XUM

In this building, after the windows were weather stripped, quite a few of the radiators were subsequently removed, and the apartments were never cold. I refer to this subject because we have drafted a resolution recommending ventilation in buildings occupied by a number of people through necessity or preference, such as theatres and factories. I recall the fact that in times past our forefathers got along with little or no artificial ventilation because of the fact that the air leakage in old buildings was much greater than those constructed in the present day. Ventilation is necessary, but ventilation coming from air leakage is not always the right kind. It is probable that if due means be taken to prevent this air leakage it will save 10 to 15 per cent. of the first cost of the installation to our customers. It is also essential that ventilation should be introduced in all public buildings through proper means or by accelerated ventilation, as this is the only way to effectually control the amount of fresh air to be admitted into a given space.

Mr. Whitten: I would like to ask Professor Kinealy if he has ever taken note of the heat loss from the syphonic action exerted by moving outside winds on sheltered sides of buildings.

Professor Kinealy: You mean the air being drawn out?

Mr. Whitten: The air being drawn out by a partial vacuum caused by the movement of the outside wind.

Professor Kinealy: Yes; I have made some measurements, but they were unsatisfactory. The anemometer I used was such that I could not very well measure air being drawn from the inside to the outside unless I stood on the outside of the building, and that I did not want to do. I measured, however, the inflow, but not nearly in so accurate a manner as you have, and my results were not as satisfactory as I would like to have had them.

In regard to filtration of air through the walls there are very few data to be had on that. The filtration of air through an unplastered brick wall is very great. The filtration through lath and plaster is very great. Any one can notice the ceiling of an ordinary plastered room and can see white and dark marks showing the lath. The air filters through between the lath and makes a dark spot. This filtration does not take place nearly so much if the surface of the plaster or brick wall is painted or even if the wall is papered. A coating of paper on the

inside of a plastered wall reduces the filtration of air through that wall to almost nothing. It is very rarely that you can see the white and black marks on a papered ceiling, but you can always see them on an unpapered plastered ceiling, provided the plaster has not been painted. That shows clearly there is no filtration of air through it. Wherever air filters through dirt and dust is deposited exactly as it would be on a filter.

There is one man who made some experiments and who gives the formula for estimating it. I haven't got the formula and have forgotten the man's name. The work, however, is published in some German pocketbook for heating and ventilating.

Mr. Barwick: Mr. Whitten's paper speaks of the loss of the amount of air that passes through windows. It is a very hard matter to settle a thing of that kind unless you know certain conditions. If you know those conditions you can figure for them.

A few months ago I checked up a good many plants and found in some cases that they would work all right under certain conditions, and would not work under other conditions. For instance, take a building with the temperature at 85 degrees to-day and the temperature outside probably 35, would that building heat to 70 degrees in zero weather? That is difficult to say, because we do not know the exact conditions. The wind may be blowing five miles per hour to-day and to-morrow fifteen, twenty or twenty-five. If you consider that we have 1/16 of an inch place around all sash (and that is the usual custom) in new work, when it has shrunk there is an entirely different condition.

In a building that I had in charge some years ago I put in a very large amount of radiation, and swore it would heat that building, and yet I could not bring that building up to over 60 degrees. The reason was the windows leaked so much, and there was so much leakage around the studding and other parts of the building it was utterly impossible to heat it.

If we are to fix a standard we must fix it on the basis that the building shall be well constructed, for that is the only basis on which we can fix any data of that kind.

Mr. Barwick: I have had considerable thought in reference to leakage of windows, but have never been able to get down

to the actual facts. Leakage, of course, is the greatest thing we have to contend with, and have to take notice of a great many figures that are being given us by experimenters such as Peclèt and others; and those who have checked up those things find they compare very favorably. Take Professor Carpenter, for example, who made some tests on the loss of heat in certain classes of building construction, and also through glass and other things. Leakage through windows is a subject that has been brought up a number of times. The first paper giving data that came out on that subject was written by Mr. Harrison. Mr. Whitten elaborated on that and brought out after a series of tests just exactly the amount of leakage through a window of ordinary construction. There are two conditions in window construction with which we are troubled. One is the infiltration and the other the outgo. It is therefore necessary in an ordinary room in which there are only one or two windows to take the upper and lower sash entirely separate. Many years ago it was stated a window would leak eight cubic feet of air per hour. That was stated by one of our oldest investigators in heating and ventilation. If you take it on that basis of eight cubic feet you will have a very small amount of air to take care of, but if you take the wind blowing at twenty-five or thirty or thirty-five miles per hour you come to an entirely different condition. That is the reason why furnace jobs do not work perfectly and satisfactory. It is not always the walls that are badly constructed, because a great many of our buildings are sheathed on the outside by a fairly good system. Our greatest trouble has been leakage through windows more than anything else. That is the reason why all the investigators along this line who are trying to form some basis by which they could test heating apparatus in the building have fallen down. Now if we put the motion to our committee that they shall investigate that matter, and get at the facts, it is up to them to get from our members and from anybody throughout the United States wherever they can get it, as many data on that subject as possible and try to make some tests. If everybody who is allied with our interests will endeavor to give us some evidence of what they have done, what they can do and what they do do, we will arrive at a standard which we can put before

them, so that they can go to a man and say: "This room is heated at such and such a temperature, and the temperature outside is so and so." We have fulfilled our contract according to the standard adopted by the Society of Heating and Ventilating Engineers.

Mr. Badger: What Mr. Barwick has stated appears to be my experience to a great extent. I do not wonder that Professor Kinealy says he is in the same position he occupied years ago when he was appointed on this Committee, and that it is a difficult problem to solve. The question has arisen in my mind how tests can be made so as to arrive at a proper basis. The varying conditions of a building are such that it requires a number of tests before you can arrive at a scale which can be relied upon. I suggest the following: Test a building at zero weather under a wind pressure of ten or fifteen miles per hour, and get the conditions existing in that case. Then make tests at freezing outside, with a similar wind pressure. It takes time, of course, to find those conditions to make such tests, but with those two tests, it might be possible to arrive at a scale that would be safe. I have in mind one building in my experience where I tested it at 8 degrees above zero on the outside, with some forty-one cubic feet of air per person per minute, being supplied to the rooms, the average temperature of the air entering being 125 degrees, and I could not get a temperature of more than 60 to 64 degrees in the occupied portion of the rooms. The leakage due to the excessive glass surface together with the wind pressure existing at that time was the reason for it. I recommended to the Board that they put on double windows which they did, and I tested that building under similar conditions a little later, and found that at about 95 degrees I could maintain 70 in the rooms under proper management of the plant. If these tests can be made, I think it is possible to obtain results which would certainly facilitate our work.

XUM

CCI.

TOPICAL DISCUSSIONS.

TOPIC NO. 3.

"Air-cooling by Air-washers."

DISCUSSION.

Mr. Braemer: During the last few years the air-washer has taken a prominent place as an air-purifier in all modern fan systems of heating and ventilation, and to-day no plant of this type is considered complete without it. But the air-washer has been found useful for other purposes than mere air-cleansing, and it is now commonly used also for humidification, air-cooling and de-humidification. As is always the case with apparatus that is comparatively new in the field, some manufacturers of air-washers have made broad general claims for results obtained by their specific apparatus, which could only be fulfilled under given specific conditions and as the heating engineers and architects so far have had comparatively little opportunity for securing reliable information on the subject, depending almost entirely upon information furnished by manufacturers' representatives, who, in most cases, had but little information on the subject themselves, numerous guarantees have been exacted in air-washer specifications, impossible to fulfil except under given conditions, which, however, were not mentioned.

Perhaps one of the features least known about and most abused is air-cooling by means of an air-washer. Claims by some manufacturers have been made to the effect that their particular air-washer would cool the air to within six degrees of the temperature of the spray water, others have claimed to cool within four degrees; again others claimed still better results, and all of these guarantees could readily be fulfilled under given condition and under that condition only.

It must be understood that the amount of cooling which can be accomplished by an air-washer depends upon four distinct points: First. Temperature of outside air. Second. Relative humidity of outside air. Third. Temperature of spray water used. Fourth. Efficiency of contact between the air and the spray water, and this again depends entirely upon the specific construction of the apparatus used.

As has been mentioned before the Society at previous meetings, air cooling by the air-washer takes place largely through evaporation, and it follows therefore that when the relative humidity of the outside air is high, comparatively little evaporation can take place, and therefore comparatively little cooling. Some manufacturers claim that automatic humidity control can be accomplished by their air-washer without the use of special devices, but it is evident that as the final humidity condition of the air depends principally upon the dry and wet bulb temperatures of the initial air and the temperature of the spray water used, and fluctuates with the variation in these temperatures, special devices and instruments will be required to secure automatic control.

De-humidification may be accomplished by an air-washer, by which is meant that moisture may be condensed from the air entering the apparatus, the absolute humidity of the air leaving the air-washer being less than that of the entering air, but in order to accomplish this the temperature of the spray water must be below the dew point temperature of the entering air, and the difference in temperature necessary between the dew point of initial air and spray water to effect a given amount of condensation will in a measure depend upon the efficiency of contact between the air and the water in the apparatus used.

Humidification, air-cooling and de-humidification by means of an air-washer present at times some nice engineering problems which cannot be solved without an intimate knowledge of the subject on the part of the designing engineer, and as to my knowledge but very little literature exists on the subject, reliable information can only be obtained from actual tests.

Mr. Weinshank: I believe that the washing of air and the cooling of the same are two separate and distinct problems. When a manufacturer or contractor who installs an air washer claims that he would wash the air and at the same time cool

it, it is my opinion that he is making an assertion to which he cannot live up to unless he states that the air washer is equipped with a separate and distinct cooling apparatus. An air washer is doing well if it washes and purifies the air.

This Society has had enough experience, and received enough information that it is in a position to create a standard the same as boilers, radiators, etc., and in writing specifications for an air washer we are in a position to state or require just what the air washer is to accomplish, but our experience tells us that when the question of cooling is involved that same must be treated separately.

President Mackay: It seems to me it is time this Society should consider this problem and refer it to the Committee on Tests. It is important.

Mr. Weinshank: I move that this question of air washing be referred to the Committee on Tests.

Mr. Chew: Are we ready to do that? We have a committee to collect data for air washers. Have the incoming President appoint a new committee if necessary. I want to say again the Committees on Tests and on Standards have for several years been the graveyard for some of the good things brought before this Society, and I am emphatically opposed to sending matters to that graveyard when you have a committee which has shown active life in the excellent reports it has presented. I hope a lot of members will follow me in opposing the motion by Mr. Weinshank that this be referred to the Committee on Tests. I think if you will leave the matter to the present committee it will attend to its duties. I think more benefit will come by having the work separated among a lot of people rather than having four or five men do it all.

Secretary Mackay: I am in favor of what Mr. Chew says to a certain point, that we should be careful what we put on our records as the standard of the Society.

Mr. Chew: As I understand it the committee has not made a report and there isn't anything to refer.

Mr. Weinshank: I am afraid Mr. Chew misunderstood my motion. My intention was not to discharge the committee on air washers or disturb any previous arrangement, but the Committee on Tests should make some report or make a series of tests of

their own. In fact, I understand some of the air washer manufacturers have invited some of the members of the Society to conduct a series of tests and have placed apparatus at the disposal of the Committee on Tests to procure any information they want. Now if the air washer committee is in a position to do the work I certainly will withdraw my motion, but if the air washer committee is to collect data and get information on air washers and not act nor make recommendations, then the question of air washing should be referred to the Committee on Tests.

Mr. Lewis: I happen to be chairman of the committee on air washers, and while we have not been able to put in a report at this time, we have had a number of invitations to make tests, and have our arrangements ready to make them, but it will take us a little time to get organized.

Secretary Mackay: I am strongly in favor of a committee finishing the work it was appointed for on any subject before the matter is finally referred. I think there should be final action, and that is why I strongly opposed yesterday when a committee that was newly appointed, and had only worked two or three months and put in no report, that the work should be taken out of their hands and referred to the Committee on Standards. I do think that the committees on different subjects should be continued with full power until they have completed their report to the Society. I don't want to see the Society appoint a committee and hamper them in any way in the discharge of their duties.

President Mackay: I want to ask Mr. McCann, who has had some opportunities to observe air washers, whether they have considered it possible that an apparatus might be introduced in some of the larger schools. If so, what are his observations on the subject of air washers.

Mr. McCann: In one school we have a modern air washer, and while I have not yet had an opportunity to make any elaborate tests as to humidity in connection therewith, there has been no complaint of excessive humidity. I am informed that several pailsful of dirt are removed from the air washer every week, which shows the value of the washer. Personally I would install air washers in every school were funds available.

XUM

TOPIC NO. 4.

"The Relative Carrying Capacity of Horizontal and Vertical Warm-air Pipes."

TOPIC NO. 5.

"The Effect of Shape on Warm-air Risers."

DISCUSSION OF TOPICS 4 AND 5.

Mr. Chew: As I understand it there seems to be what I would consider a popular delusion, as to the velocity in the vertical pipe used in furnace heating in partitions that has been the curse and bane of that system of heating. Some seem to believe that even though the area of the partition pipe may be only one-third of the area of the horizontal pipe it carries away all the air that will flow in the horizontal pipe two or three times, notwithstanding the horizontal pipe is circular in form, presenting the least friction possible to the flow of air through it. A vertical pipe is generally of a depth that is one-third of its width, and presents an abnormal amount of friction. It is impossible to be sure that the full area is available which would be calculated from the dimensions, because in applying the plaster over the partitions in which such flues are run it is not uncommon for the pressure of the moisture to force the sides of the flues in. I doubt if with a flue 4 x 12 inch there would be an area at times of more than 35 to 36 square inches of area, where the figures say 48. One of the members of this Society sent a paper several years ago to the effect that the flow was so rapid in the vertical riser that it required a much larger pipe in the cellar, and when asked for the basis of his conclusions so it could be incorporated in a paper and properly come before the Society it was never furnished. No authoritative information on that subject has come to the Society. Professor Hoffman says something in his paper to the effect that the vertical flues of the right size are not generally used.

Mr. Snow: I was interested in what Mr. Chew had to say. He did not call attention to the fact that 2 x 4 inch studs run about 2 x 3¾ inches, so that the lath are only 3¾ inches

apart on the inside, and the plaster and the jamb take off a quarter of an inch more. That quarter of an inch was the only point I wanted to bring out. By furring out on studs with the ordinary 1 x 2 inch furring strips we use in houses there is no doubt but what the capacities of the flues are greatly increased over what they would be if of the same area, but placed between 2 x 4 inch studs. I think the influence of furnace men should be along those lines in talking with architects and those who have charge of this work. The furnace men should insist if possible on 5 inch studding. It has taken a good many years to bring furnace heating where it is to-day, and, of course, there are a good many of the old school engaged in this work, who no doubt would say it is hard work to teach an old dog new tricks. The younger generation that is coming up I am sure is going ahead on different lines. There are conditions which detract greatly from the efficiency of furnace heating. There are second class buildings where furnace heating is a very desirable system to use. I think there is no doubt that owing to the ignorance with which these systems are installed the system has in some sections received a black eye. What the Society has done through these committees and through such papers as Professor Hoffman presented yesterday should be of assistance not only to persons engaged in that class of heating, but, taking a broader outlook, we should always keep in mind we are doing welfare work. We are establishing standards which make failures fewer. These have been all too common in the past, due to ignorance of rules and data which are familiar to those of us who are members of this Society, and that class of information should be disseminated as widely as possible through the trade and engineering papers. Furnace heating is not obsolete by any means. It has its field and it should receive consideration at our hands to secure the best methods of installation so far as possible, and to educate the architects, as a good many of them are quite lax in their interest in some of these things. We can do a good deal of work along that line.

Mr. Lewis: I suggest the use of vitrified sewer tile for hot air risers and for horizontal pipes. I have used this tile for smoke pipe with satisfactory results and see no reason why

it would not make very successful and economical hot air risers.

Mr. Lewis: I would suggest the use of some sewer pipes for risers and possibly for horizontal pipes. I have never used them for horizontal pipes except for smoke pipes, in which they have proven very satisfactory. I see no reason why you should not run the stack up. It would cost very little more and last longer.

Mr. Vrooman: I had a case recently, where I set a hot air heater and connected it to hot air pipes, previously installed in the building by another party. One of these pipes, about 3½ x 11 inches, passed up through the outside wall of the frame building with a square turn at the top to a horizontal pipe from which a branch was taken at right angles to one of the registers; the other register was taken from the top of the horizontal pipe beyond the branch. No heat would come out of either of these registers. We took the horizontal pipes under the floor out, and built them over, making a round turn from the vertical to the horizontal, and increasing the horizontal to 7 x 11 inches, also made a round turn to the branch pipe with a deflector opposite it, and both registers supplied plenty of heat.

Mr. Schaffer: My practice is not to use anything larger than a 9 inch horizontal pipe on a 4 x 12 inch riser. I find that is ample in my work. That is the answer to Mr. Chew.

Mr. Chew: Several years ago R. S. Thompson presented a paper on furnace heating, and after we had printed it in the *Metal Worker* I kept the type standing and took off some hundred copies, and with the permission of the Society read it before another national body. The result of the reading of that paper was a conference committee of heating contractors and manufacturers, and the result of that was the formation of another national body for the uplift of furnace heating. I want this fact to go on record, so the Society will have it in its archives. The uplift which is going on in the United States today in the interest of furnace heating found its origin in this Society as a result of a paper prepared by one of its members.

We are proud of the fact we have secured ventilation laws in different States, and I believe that we can take pride in this piece of work.

There ought to be some authoritative answer presented for the benefit of the trade on what Mr. Schaefer has said about using nothing larger than a 9-inch pipe in connection with a 4 x 12-inch riser.

Mr. Austin: I think in some cases it is all right to use an eight-inch pipe, and sometimes a larger size. It depends on the length of the pipe. Sometimes the pipe comes off from the furnace only a few feet and sometimes fifteen feet. The total friction is due to the floor to which the air goes, second or third, and the size of the horizontal pipe depends on its length to a great extent, sometimes 3 feet and sometimes 15 or 20 feet. You cannot fix a standard for that.

Mr. Schaffer: That is correct. I do not use any larger than that, and in some cases smaller.

TOPIC NO. 7.

"The Necessity for Having Ventilation Laws Applying to the Installation of Apparatus in Old as Well as in New Buildings."

DISCUSSION.

Secretary Mackay: In a State where they have a compulsory legislation law applying to school buildings, I was called in as an expert to determine whether the heating contractor had fulfilled his contract. So far as the plans and specifications were concerned, he had, but in my report I said:

"While there is nothing in the proposition or the specification that refers to it, there is a law in your State applicable to all new school buildings and to all additions on improvements in existing buildings which calls for 30 cubic feet of air per minute for each pupil in all rooms occupied as school-rooms.

"Some of your school-rooms have seating capacity for fifty scholars, some less, but taking the rooms as averaging forty pupils (forty-two was the greatest number present in a single room when I was there) you would require 72,000 cubic feet of air as necessary for each room per hour.

"Your present system as placed would, if the outlet registers were enlarged and additional heat applied at the base, and the vent flues kept heated, give you not to exceed 18,000 cubic feet

of air per room or 25 per cent. of the requirements of the state law, per hour."

A committee of some fifteen members had discovered and told me that while the law applied to new buildings it did not apply to old buildings.

I was called in in the same State on another building that had originally been heated by two hot air furnaces. There was no attempt at ventilation. The heating contractor had been asked to put in another furnace, which he did, with no better results than that they had an additional capacity for burning fuel. The basement was overheated, but there was little or no heat in the rooms on account of having no way of extracting air. This had gone on for eight or nine years, and they decided to put in a heating apparatus. I called their attention to the necessity of ventilation. They, also, told me that as their building had been erected the year previous to the enacting of the law they were exempt from it, and that they didn't have to do that. I took the matter up with the State Superintendent of education, and he told me that they were right in their contention that the law did no apply to it. I wrote him that I felt it my duty as a member of the American Society of Heating and Ventilating Engineers to bring this matter before this Society.

My contention is if ventilation is a necessity in a new school building, it is more of a necessity in a building that has been used for eight to twelve years without any ventilation, and that as a Society through the Legislative Committee we should attempt to have the law which so well applies to new buildings extended so as to apply also to buildings that have been erected for some time, particularly where they are installing a new system of heating and ventilation.

In some States that matter comes under the Board of Health, they having the power to condemn any building that is not, in their judgment, in a satisfactory condition for the purposes for which it is intended, or the building can be closed until such time as changes are made in it that make it satisfactory.

In one case they spent four or five thousand dollars, and two thousand more would have given the six hundred children occupying the building ventilation that they are getting in the best constructed schools to-day, but this body of men who were supposed to be intelligent are allowed to rule that these six

hundred children shall have no ventilation, while in the next county or State they say it is necessary that the children in every school must have ventilation. It is a crying shame that we as a Society should allow this to go on.

Mr. Hall: I am glad of the privilege of meeting with this distinguished body of men. I believe the work you are doing not only in New York State but throughout the United States is one that is to be commended.

This subject of ventilation of old buildings is one of special interest to the State Educational Department of this State. Last evening some one remarked the State of Massachusetts is doing a wonderful thing in the line of heating and ventilating their school buildings, and that New York State was doing something along the line of ventilating factories. The progress made in regard to school buildings, in regard to light, heating, ventilation, floor space and air space, has been the most remarkable progress that has ever been made in any State in the past four years. Four years ago a law was enacted which covered this point, at least no school building could be erected in the State hereafter nor any addition made to any old building where the cost exceeds $500 until the plans and specifications are approved by the Board of Education.

The State Educational Department has emphasized the fact that it is just as essential that old buildings should be heated and ventilated as new ones. When it comes to the question of approving plans and specifications there is nothing in the law which gives that power whatever. We have insisted if plans were approved they must meet all the requirements of a new building, and it was not necessary for the Board to submit plans covering old buildings.

The State Educational Department is in sympathy with any movement relative to new buildings and old buildings. Of course the State Department only acts in cities of the third class, villages and country districts. Second and third class cities are exempt. People of the first and second class have their own facilities.

We are heartily in sympathy with any action of this Society, and if the matter is finally referred to the Legislative Committee and a bill drafted, I can assure you the Educational Department will coöperate with the Legislative Committee to see the bill is

passed and will carry out at least some of the phases of the new building.

Mr. Scollay: I think this question of ventilating existing buildings is a very important matter. This Society should connect itself with any movement looking towards that end. It is a fact that there are as many students being educated in old buildings without adequate ventilation as are being educated in modern buildings. Coming down to my own case, my son has been educated in the Adelphi Academy in Brooklyn. It is a very old building. The only ventilation it has is by means of a few indirect radiators. I have taken the matter up several times, but it is impossible to accomplish anything. I think there ought to be some movement towards telling the people who own these private schools as well as the cities who own the public schools to properly ventilate the old buildings. I believe that a committee ought to be appointed by this Society for advocating improved ventilation of old buildings. It is a very important question, and we ought to take some action on it.

Secretary Mackay: I hope some expression, favorable or unfavorable, will be given out at this time. I think that purely comes under Art. I of our Charter.

Mr. Lewis: I would like to suggest we have in every State a committee on compulsory ventilation. There are only three or four States that have compulsory ventilation. Why don't we have a committee in every State.

Secretary Mackay: Some years ago a committee was appointed in every State, and their reports are part of the Proceedings of this Society.

TOPIC NO. 8.

"State Control for Heating and Ventilating Engineers."

DISCUSSION.

Secretary Mackay: I am the one who proposed this topic. I thought that as doctors, druggists, veterinary surgeons and chiropodists are put under restrictions, that it was possibly right for our Society to move in the matter of State control of heat-

ing and ventilating engineers, my principal idea being that a competent heating and ventilating engineer be protected in his specialty, as is done in other professions, and that the incompetent be prevented from bringing discredit on the profession, as we probably have all seen it from time to time. That was my object in introducing the topic, and I hope it will be discussed and that some action will be taken by the Society which will lead to that end.

Mr. Badger: I am in favor of State control of the heating and ventilating engineers, at least to the extent that they should be required to pass an examination and secure a license before they could use the title. All those who are eligible by technical or practical experience could pass this examination and secure these licenses. This would not only protect the legitimate engineer, but would to a great extent impress upon the public mind the importance of our profession, and lead those, who may be either compelled by law to ventilate, or who may be considering this subject, to entrust their work only to such men as have the experience and ability.

No doubt the most of us, if not all, have had much to contend with in advocating the proper ventilation of buildings. In my opinion a law requiring the passing of an examination before a license could be secured would help to overcome some of these difficulties.

Professor Kinealy: I am opposed to State control. It seems to me it would be difficult to establish a standard unless it be a standard we have already established in this Society. If you have State control you must have some standard. The man who applies for his license must be known to some one as a man competent to erect, install and design heating and ventilating plants. That means he has to have qualification for membership in this Society, so if we have State control we practically have to have a law saying in order to practice in the State he must be a member of this Society. Isn't it far better for us to make our Society such that the public will know a man a member of this Society is fully competent. Let us impress that upon the people and we will need no law.

Secretary Mackay: If we as a Society can exert influence in any section of the country, it will be where we are strongest, in such States where our legislative committee can secure

recognition. I believe it is the proper thing to do, to help uplift the entire profession whether members of our Society or not.

I move the matter be referred to the Committee on Compulsory Legislation for action.

Mr. Donnelly: I think what Professor Kinealy has said covers a good deal of the question correctly. I think the tendency is towards less law rather than more law. I think it would be difficult for this Society to take the initiative.

The question would arise as to the lines of professional work which are now under State or government control. I think that would be confronted at once with the question whether the mechanical engineer, the civil engineer, the mining engineer, electrical engineer, and many other men who practice one or more of these professions, have to pass an examination along those lines.

Another very serious phase of the question seems to me to be the fact that it takes so little for a man to be a thoroughly competent heating and ventilating engineer in some particular line. That may be the line in which his occupation brings him.

I think we should follow the example of Chicago and have local Chapters in every State where we have sufficient members. I think this could be handled better by local Chapters than by State control.

Mr. Kinealy: You have expressed my idea exactly. No man could undertake to pose before the public as a mechanical engineer and undertake the designing, superintending and construction of large works, unless he was a member of the Society. So, too, I think that no man who does not possess the qualifications for membership in this Society could pose as a heating and ventilating engineer. I have been careful to say "possessed the qualifications." I do not mean that he is necessarily a member. There are many heating and ventilating engineers who possess all the qualifications of the Society who are not members. The mere fact that a man is a member will mean to the public that that man has been looked over, his record has been looked into, his qualifications studied, and he has been passed upon and voted upon by a large number, and not only is he a competent designer, as an

engineer, not only has he the technical knowledge, but he has been voted on by several hundred men who know he is honest, reliable and trustworthy.

Mr. Badger: I want to see this Society recognized to the extent that the standards it proposes, and what it advocates, shall be considered authoritative, and, therefore, worthy of consideration above all other Societies, or opinions expressed, in connection with heating and ventilating. The principal object I have in favoring State control is based upon this proposition, but since we cannot compel those who wish to follow this profession to become members of our Society, or compel those who are considering the ventilation of their buildings to employ only engineers who are members of this organization, I thought possibly a law could be secured by which the title of "Heating and Ventilating Engineer" could not be used except by passing a proper examination required by the State. With such a law, the public would attach some importance to our title, and a better recognition would undoubtedly be given our Society, and thus better protection afforded the reputable engineers.

Secretary Mackay: Mr. Donnelly says sanitary engineers are not under State control. It is impossible in the State of New York and many other States for a sanitary engineer to design sanitation for a building without having the approval of some inspector appointed by the State or local government, and it is impossible for that work to be installed except by a licensed master plumber. They take life in their hands and the State recognizes it.

I know of a case of a man who because of the jealous feeling in his community is prevented from getting a license as a master plumber, and it is impossible for him to practice his profession. They have recognized the necessity of supervision over the work of sanitary engineers. I think the question of life and health is as great in the case of the heating and ventilating engineer as in the case of the sanitary engineer.

I think every member of our Society will agree with me when I say there are millions of dollars for heating and ventilating apparatus wasted every year by incompetent designing, by either incompetent engineers or men who are not heating and

ventilating engineers at all. They are misleading the public, are spending the public's money, and we as a Society should do what we can in connection with that as well as for the adoption of proper legislation. We ought to bring it to the attention of the public that they require competent heating and ventilating engineers.

Mr. Vrooman: I believe that to take this to the State and ask for a law would deteriorate from the profession, and from the Society more than if a different course were taken. I have in my hand an application for membership in this Society. After stating where born, age, etc., it says: "Education, preparatory and technical schools, degree, date of apprenticeship, draughting experience, where it was, shop experience, and other practical experience." I think that experience counts for a great deal and should be sufficient to entitle an applicant to become a member of this Society. I do not know if any of the colleges and technical schools to date have adopted any course whereby they give a degree that carries with it the profession of heating and ventilating engineer.

As to the inspection and the matter of licensing some tradesmen to practice, as in the case of a plumber, he has to have his plans inspected and passed upon by the inspector of that locality, but first gets his permission to practice by examination. As to civil engineers, the degree issued by many of the colleges to-day is not C. E. The graduate has to wait some years before he can get that, and then has to pass more examinations to meet some other requirements.

I think a law governing the case would be detrimental to the Society. I think a better course would be to get the degree of some school or college which would be of more value than State law.

Mr. Seward: I think that this Society is recognized a great deal more than some of us appreciate. I had occasion recently in connection with some committee work to write to all the colleges in this country relative to data which they had in connection with the subject I was investigating. I wrote them as a committeeman of this Society, and it was extremely gratifying to see the replies of the various professors of engineering in those colleges. I was amazed at the interest

they took in the matter, and the readiness with which they responded. I believe the time is coming when the ability of a man to say he is a member of this Society is going to be all the endorsement he needs as a heating and ventilating engineer.

President Mackay: I think dignity and well-directed sentiment will bring about this condition. One of the weakest points in our whole armor is lack of sentiment. The public does not know the needs of ventilation. Every movement in every State made by our legislative committee has brought this out, that they are not alive to the needs of proper ventilation; they do not know it—the rank and file—and we should, every individual, spread the proper sentiment as a member of our organization.

The motion to refer to the Legislative Committee was seconded and agreed to.

Mr. Whitten: I want to say that I have had two conversations with physical directors, so-called, in two of the largest cities of the country. I believe they have some sort of an association, and they are directly interested in this question, and that being the case I would suggest to this Society to get in some manner in touch with those people who are making a study of this matter from standpoints other than our own, and I am sure we will get some ideas from them.

Mr. Badger: The National Educational Association some years ago appointed a committee for the purpose of drafting a bill to be presented to every legislature on compulsory ventilation. I do not know how far they have gone in connection with that work, but I would like to know if our Society has coöperated to any extent with the National Educational Association. I understand that association is composed of representative educational men of the United States and is a very strong organization.

President Mackay: I think not as a body. Some of our members have.

XUM

TOPIC NO. 11.

"The Maximum Permissible Length for a Steam Main in a Gravity Apparatus Operating Under a Pressure not to Exceed Two Pounds on One and Two-Pipe Systems."

DISCUSSION.

Mr. Barwick: With reference to that topic, that is a matter that is up before our Committee on Tests. I think they have examined into it very carefully and have looked over all sorts of methods, and a great many of the figures they have got amount practically to what we are all doing.

Mr. Donnelly: Some time ago I had an unusual opportunity of observing the drop in pressure in a steam main about 2,600 feet long. It was a 16-inch pipe supplied with steam, and by a thermometer we found the temperature was 214 degrees. It ran underground for fully 2,600 feet. It was covered by a dark brownish felt, with no pipe covering or other insulating material. The drip was taken out from one point only, at the extreme end of the 2,600 feet. The condensation was probably twelve or fifteen per cent. of the steam carried. The temperature at the 2,600 foot point as I remember now was 208 degrees. The drop in pressure is about one pound and a half for the 2,600 feet.

Mr. Bishop: I had in mind a line supplying about 296,000 square feet radiation through a 16-inch line. It was about 6,000 feet long and the drop ⅜ of a pound per 1,000 feet.

Mr. Barwick: I put in an underground plant running 1,000 feet from the boiler to the building. We were operating under 50 pounds gauge pressure. In the building we found we had a drop of one pound pressure. That is the only drop that we found. It may be that the insulation was very good. The main was at an average depth of say four feet, although in some places it was only two, and in other places it was seven, but we only had that amount of drop.

TOPIC NO. 12.

"The Relative Area of Wet and Dry Return Mains in a Gravity Steam Heating Apparatus."

DISCUSSION.

Mr. Munroe: I must confess I have not prepared anything to bring before the Society this afternoon. This table that has

been put into my hands was compiled nearly two years ago, at which time I gave considerable thought to the subject of size of steam and return mains. It was prepared and furnished to *Domestic Engineering,* the substance of four different tables that I have revised or completed during the fifteen years I have been in business. A table that I have used in my own practice, and as far as I knew there was no other authentic information on file. It is practically if not theoretically correct. In gravity systems this table may be applied as to the small sizes. It is not likely that any of us will come up against a proposition where, for instance, taking the larger sizes, 20,000 feet of radiation will have to be placed on a ten-inch return main. I do not think I ever saw a drawing of a gravity system that was quite so extensive, or even as to the next size, 11,500 square feet. When we design plants of these dimensions we generally use one of the vacuum systems where a pump is used. I will say in substantiation of my figures, it is a fact that, in the case of a wet return, the quantity of water in a long return line is so great that if you should maintain the sizes necessary for circulation by gravity in a dry return, the heat that is thrown off will bring the water back to the boiler at a very low temperature which is, of course, disadvantageous. Therefore, I make a general reduction in the size of the wet returns for long runs over those required for dry returns, which I do not think is far from being the correct idea. If there is any good reason for not doing this I will only be too delighted to have some one correct me and speak freely on the subject.

Mr. Donnelly: The question was asked about wet and dry return mains, and as the discussion was revised afterwards it read as follows:

$$r = R\frac{40}{1 + .4n.}$$

I will say that this formula was checked up by Mr. Macon and published in the *Metal Worker,* and translated and published in France, the table translated into the metric system.

TRANSACTIONS

OF THE

SEMI-ANNUAL MEETING

Indianapolis, Ind., July 15, 16, 1909.

XUM

SEMI-ANNUAL MEETING, 1909.

First Day—Morning Session.

Indianapolis, Ind., July 15, 1909.

The meeting was called to order at 10 A. M. by President Snow.

Secretary Mackay: Before calling the roll I would announce the names of the following persons who have been elected to membership since the last meeting:

William E. Austin	Member.
John H. Bacon, Jr	"
William A. Baker	"
Fred C. Bartley	"
James B. Bladon	"
David S. Boyden	"
Samuel S. Clarke	"
F. E. Colby	"
A. G. Cripps	"
N. Loring Danforth	"
John G. Eadie	"
David S. Ebinger	"
Sidney E. Fenstermaker	"
George V. Greey	"
Harry H. Hess	"
Fred B. Hofft	"
George Huey	"
Albert W. Kerr	"
Max J. Mulhall	"
James W. H. Myrick	"
Herman W. Nelson	"

XUM

Edward Norris	Member.
Herbert E. Raymond	"
William Ritchie	"
Geo. M. Tait	"
Melvern F. Thomas	"
Geo. O. Titcomb	"
Herbert W. Whitten	"
John E. Williams	"
Louis D. Collins	Associate.
Harry W. Ellis	"
Chas. B. Kennedy	"
Frank Schreidt	"
Harris B. Johnson	Junior
Frank D. Sharp	"

The roll was called by the Secretary and announced that a quorum was present.

President Snow then read the following address:

We have gathered for the summer meeting of the fifteenth year of the existence of the American Society of Heating and Ventilating Engineers. A striking degree of interest in this organization has been manifested of late. On our recent ballot, the largest in our history, 27 new members, 2 juniors and 5 associates were elected. One feature that augurs well for our future success is the willingness of many of our members to give freely of their time to important committee work. This is a real sacrifice made by a few for the benefit of all.

We have always given freely through the engineering and trade press of the fruit of our meetings for the benefit of the public. Occasionally the courtesies we have extended have been misused. It is not expected that reports of our meetings shall be as complete or as accurate as the contents of our proceedings. Inaccurate reports reflect anything but credit on our Society.

The value of this Society to its members is to be measured not only by what they can extract from it, but by what the members can contribute to it by papers or discussions as well. Carefully prepared papers are a valuable training to the contributors of such papers. I hope that our younger members will appreciate this, and will bear in mind that it is time that some of our older

members who have done so much for us in the past be relieved of some of their responsibility for the success of our meetings.

Papers to be of the greatest value must be in the hands of the Publication Committee and the secretary sufficiently in advance of the meeting at which they are to be read to permit of their being printed and distributed in time to give members an opportunity to read, study and prepare a discussion of them. I wish to emphasize this, as members have been prone to overlook the necessity of submitting their papers well in advance of meetings in order that they may be of the greatest value.

This Society stands for the engineering side of heating and ventilation. To be successful it must be kept free from commercialism. We have our trade organizations. Let it be emphasized, then, that this Society is purely for engineering. Let the members come here with a serious purpose to advance its interests, so that our standards will be the recognized ones and our aims will command public support. Our Society is rapidly gaining in size, and I believe in the quality of its membership. Let our aims be high, and let us not forget our duty to the public.

Every year, as we all know, immense sums are wasted through faulty installations due to no desire on the part of the contractor to take advantage of the ignorance of his customer, but due to lack of knowledge of some of the principles of heating and ventilation. Standards are needed for the protection of the layman and for the guidance of the contractor. Our committees are at work on such standards, and their adoption when perfected will add to the usefulness and prestige of our Society. Not only are standards needed to secure successful installations so far as accomplishing the desired ends as to heating and ventilation, but with higher fuel costs greater attention must be paid to economical operation, to a better understanding or the relative advantages of different systems and to securing on the part of purchasers a better appreciation of the fact that there may be other items more important than the first cost which should determine the selection of a heating and ventilating apparatus.

This Society has done much valuable work in securing compulsory legislation; much more work of this character is needed. The sufferers in our workshops are not in a position to take the initiative in ameliorating their condition. We owe it to them to do all in our power to see to it that the conditions under which

they must work are made sanitary. At this time when the public is being educated to the fact that fresh air and plenty of it is not only a preventive, but a cure for certain diseases, we must do all we can to assist in this work.

We have a Publicity Committee which I believe has a broad field of usefulness before it. It will be the function of this committee to arrange for the dissemination of knowledge pertaining to ventilation. Assistance will be needed from members scattered throughout the country, and I commend its work to you and bespeak for this committee your cordial co-operation.

It is with deep regret that I mention the death since our annual meeting of a former vice-president and charter member, T. J. Waters of Chicago, one whose work reflected credit on this Society and who did much to advance its interests. One of our past presidents, John Gormly, has found it necessary on account of ill health to retire from business and has resigned from this Society. It was with regret that his resignation was accepted.

Our constitution is not mandatory in regard to our summer meetings, but they have been so enjoyable and have served to promote good fellowship to such an extent that doubtless they may be considered a permanent feature in the conduct of the Society. While good fellowship abounds at all our meetings, this should be particularly true of those held in the summer, when nature is at her best and beckons us to drop for a time the cares and responsibilities that are a part of the existence of most of us.

Here is this beautiful city; let us give the necessary attention to the serious part of our meetings, but let it be an occasion when members will get in close touch with each other, when East meets West and North meets South, and that as a result we shall all be in full sympathy with each other and with the objects of this Society as set forth in its constitution and shall be ready one and all to co-operate to secure the attainment of those objects and to build up the prestige of this organization.

President Snow: Gentlemen, the next item on the order of business is communications from chapters.

Mr. Hale: Illinois Chapter wishes to report a happy condition, but inasmuch as the Society expects to report at the annual meeting, no regular report has been prepared for this meeting. We have taken in two new members in the last year

and lost one by death, which leaves a membership of thirty at the present time. We have held regular monthly meetings from October until May and every one of the meetings has been well attended. The interest seems to be the same as in the past years, and it certainly looks as though other states should form local chapters in order to get the real good out of the Society. We find that the good-fellowship of a chapter is very beneficial—brings us together in a way that the annual and semi-annual meetings would not permit.

President Snow: The report of the committee to collect data on fan blast heating will be read by Prof. Carpenter.

Prof. Carpenter: Previous to reading this report I wish to say that most of the work of this committee has been done by the chairman, our President. He thinks that the committee have gathered together some rather important and valuable data. There was a series of questions submitted and the report gives the answers to those questions which were made by a single firm. The answers are quite full and were, in the opinion of the committee, well worth publishing.

The report was discussed by Messrs. Hale, Davis, Donnelly and Carpenter.

It was moved by Mr. Macon, seconded by Prof. Kinealy, that the report of the Committee on Fan Blast Heating be received and the committee be discharged, and the report be referred to the Committee on Standards for recommendation to the Society. (Motion carried.)

REPORT OF THE COMMITTEE ON FAN-BLAST HEATING.

This final report of your Committee concludes those presented at the January meetings in 1908 and 1909.

Replies to the questions in the 1908 report have been received from one other manufacturer as follows:

Q. 1. Please send elevations, sections, etc., showing clearly the construction of your standard heater sections.

A. 1. Illustrations were sent.

Q. 2. What size and kind of pipe do you use?

A. 2. 1-inch steel.

Q. 3. What size and kind of fittings do you use?

A. 3. 1-inch cast iron.

Q. 4. What distance do you space your pipes between centres across the face of the heater, also the direction the air flows?

A. 4. 2¾ inches.

Q. 5. How are sections connected together; by manifolds, headers or flanges, and where or when do you use the several methods?

A. 5. With cast-iron manifolds, wrought nipples and flanges. We use this manifold on factory work only; for Public Building work the connections are always made by steam-heating contractor.

Q. 6. What depth do you advocate making the coils in rows of pipe, for (1) outside air, (2) return air for c, d, e, f?

(a) Live Steam, heating public buildings?

(b) Exhaust Steam, heating public buildings?

(c) Live Steam, heating factories?

(d) Exhaust Steam, heating factories?

(e) Live Steam for dry kilns?

(f) Exhaust Steam for dry kilns?

A. 6. (a) We believe it very uneconomical to use live steam for heating purposes for Public Buildings, or to ever use anything but fresh air. Whenever our advice is asked, and where there is not enough exhaust steam available, we should use a pressure-reducing valve.

(b) 20 rows.

(c) 20 to 24 rows.

(d) Never less than 24 rows. If fresh air is used, sometimes 28 rows.

(e) We do not believe that blowers should ever be used for drying the ordinary grades of lumber. For certain special classes of lumber such as soft maple broom handles, gum barrel staves either for slack or tight barrels or cottonwood staves, the blower system is the only system to be used. The heater should be at least 24 rows deep for live steam or 32 rows deep for exhaust steam.

Q. 7. What is the ratio of free area between the pipes to the "over-all area" of a section?

A. 7. Roughly, about 50 per cent.

Q. 8. What is the maximum allowable velocity of air through a heater section as determined by you:

(a) For public buildings?

(b) For factory buildings?

(c) For dry kilns?

A. 8. (a) 1,000 feet.

(b) 1,500 feet.

(c) 1,500 feet.

Q. 9. What temperature do you consider the air should be heated to, to give best results with a tempering coil?

A. 9. 50 degrees.

Q. 10. How many rows of pipe do you allow for:

(a) Tempering coil?

(b) Heater coil?

A. 10. (a) From 4 to 8, depending upon space conditions.

(b) From 8 to 12.

Q. 11. Do you advocate blowing through or "drawing" through a heater? Where and why?

A. 11. For most Public Building work, we advocate blowing through, because it is usually easier to arrange for by-passing the air for tempering purposes. On Public Building work, we use a "draw-through" heater only when space conditions make it necessary. On factory work, we use a "draw-through" heater almost entirely because of space conditions.

Q. 12. How do you determine the maximum temperature obtainable with varying depths of heaters, velocities and steam pressures?

A. 12. From temperature and velocity charts A and B, showing final temperature of air leaving heater made up of sections having 4 rows of 1-inch pipe each, spaced 2¾ inches on centres, temperature of entering air 0 degrees Fahr.

Q. 13. How do you determine the heat units given off per square foot of heating surface per hour with varying initial temperatures and velocities of air, and steam pressures; also the condensation under same conditions?

A. 13. The Relative Condensation in Heater Sections of 4 rows of 1-inch pipe each, spaced 2¾ inches on centres, entering air 0 degrees Fahr., average air velocity between pipes 800 feet per minute is:

1 4-row section.....1.48	5 4-row sections.....1.08
2 4-row sections.....1.37	6 4-row sections.....1.00
3 4-row sections.....1.25	7 4-row sections.....0.95
4 4-row sections.....1.175	8 4-row sections.....0.85

Q. 14. What has been your experience with cast-iron pipe or other indirect radiation besides pipe coils?

(a) Has it been as effective as a heating medium?

(b) What is the comparative efficiency?

A. 14. As we are manufacturers of pipe coils and not of cast-iron radiators, our answer to this question would necessarily be biased and, hence, not given.

Q. 15. What type of radiation do you recommend for hot-water heating?

A. 15. A mitre section [having vertical supply header and horizontal return header]. We recommend the same type of section for either gravity circulation, or for forced circulation by pump, but we would not advocate a gravity hot-water system for blower work.

Q. 16. How do you compute the size of steam mains and returns for heaters supplied with steam at varying pressures? Also for hot-water circulation?

A. 16. Have no good rules for this.

Q. 17. Do you regularly make provision for the removal of air from the radiation? If so, where and under what conditions of operation?

A. 17. With our standard heater we get very good results without any special provision for removing the air from coil.

Q. 18. Do you consider air valves either a necessary adjunct or a means of increasing the efficiency of the type of radiation you make?

A. 18. We do not.

Q. 19. Do you make any addition to or deduction from the amount of radiation, as commonly determined by the rules or formulæ you employ, if any one of the several "Vacuum Systems" is attached to the heater?

A. 19. We make neither addition nor deduction from the amount of radiation as commonly determined by our method of figuring if any one of the several "Vacuum Systems" is attached to our heaters.

LOW PRESSURE 5 POUNDS.

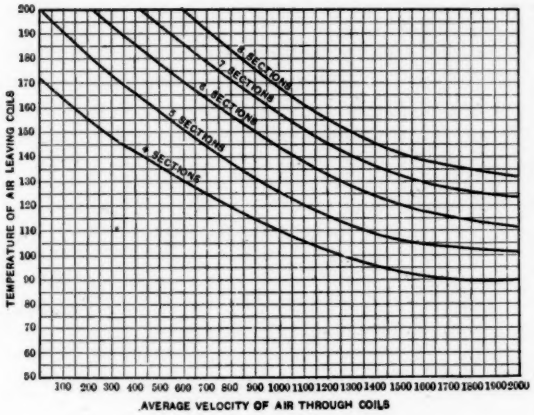


CHART A.

LIVE STEAM 80 POUNDS.

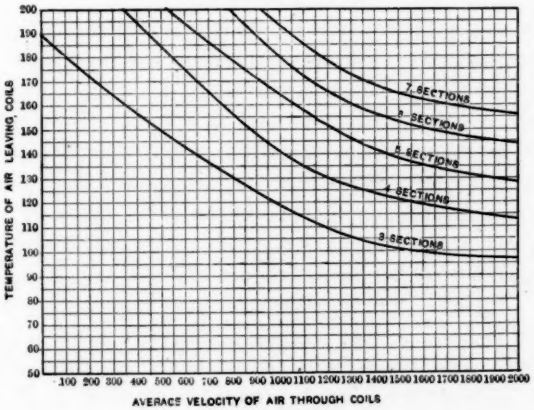


CHART B.

While illustrations of various types of heaters might perhaps have been included to advantage in this report, it has not seemed necessary to do so, since these may be had for the asking from the several manufacturers.

Although as many replies were not received as your Committee had hoped for, it is believed that the data secured will enable the Committee on Standards (to which these data are to be referred) to arrive at some conclusions which will be of value to the Society.

WM. G. SNOW, *Chairman*,
R. C. CARPENTER,
J. H. KINEALY,
F. R. STILL,
} *Committee on Fan-blast Heating.*

President Snow: The next business is the report of the Committee on Standards Relative to Boiler Rating. I will ask Prof. Kinealy to read his report on this interesting subject.

The report was read by Prof. Kinealy.

REPORT OF THE COMMITTEE ON STANDARDS AND THE COMMITTEE ON BOILERS OF THE A. S. H. & V. ENGINEERS.

Mr. President and Gentlemen: Your Committee on Standards with your Committee on Boilers, forming a joint Committee, have worked hard since the January meeting of the Society upon the subject of Rating Cast Iron Boilers, which was assigned to us at the January meeting.

We are not prepared at present to submit a final report, because we have not yet completed our work. This report is only a report of progress in which we desire to tell you what we have done and to ask that you bear with us until the next meeting, when we hope to have our work completed and to be able to submit to you a final report embodying a standard rating for cast-iron boilers. We have arrived at a scheme about as follows:

We will establish a standard rating, based, in accordance with the instructions given to us by the Society at its meeting in January, 1909, upon the rate of combustion per square foot of grate surface and the efficiency; and in order that those manufacturers who consider that their boilers should be rated higher than the standard rating may have an opportunity to

prove their claims, we are considering recommending that there be established a Board of Appeal to whom manufacturers may submit evidence in regard to their boilers and ask for a higher rating. Our idea is that where this Board of Appeal considers that a boiler is entitled to a rating higher than the standard rating, it will so certify and thus give to this particular boiler whatever rating above the standard rating the Board may consider proper.

In considering what shall be the standard rating of boilers of different sizes we have agreed:

1. That standard coal shall be anthracite coal having a heating power of 13,000 B. T. U. per pound of dry coal;

2. That one square foot of direct radiation steam surface, with steam at 2 pounds pressure in the radiator and a temperature of 70 degrees for the surrounding air, will emit 250 B. T. U. per hour; and that one square foot of direct radiation hot water surface, with water at an average temperature in the radiator of 160 degrees and a temperature of 70 degrees for the surrounding air, will emit 150 B. T. U. per hour.

3. That the grate area of a boiler shall be the opening in which the grate is placed, measured to the outermost limits of air openings.

4. That the standard ratings shall be for boilers under average working conditions.

We have not yet worked out in detail the method whereby the Board of Appeals shall be appointed nor the number of members to serve on the Board.

We have had a meeting with the members of the Boiler Manufacturers' Association, and they have consented to give the matter of rating boilers their careful consideration, and we expect to hear further from them in the fall.

We have had the question of boiler ratings under consideration with a committee appointed by the Master Steam Fitters' Association and this committee has agreed to coöperate with us and to give us the benefit of their experience.

On the whole, your Committees are able to report that a great deal of progress has been made and that the question of rating boilers is in a very satisfactory condition, and we think will have been thoroughly thrashed out to a final conclusion by the time of the annual meeting of the Society next January.

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We trust that the Society will be pleased with this tentative report and will await our final report, which we hope to submit at the next meeting of the Society.

Respectfully,

J. H. KINEALY, *Chairman.*
WM. G. SNOW, *Member Ex-officio.*
WM. M. MACKAY.
JOHN R. ALLEN.
H. A. SMITH.
A. B. FRANKLIN.
W. L. BRONAUGH.

Prof. Kinealy stated that Mr. Seward, of the Committee, did not approve the report, and that Mr. Densmore had not been heard from.

DISCUSSION OF REPORT ON BOILER RATINGS.

Mr. Davis: I would like to ask Prof. Kinealy what he means by the average working days of a house boiler. Have you established any stated intervals at which the boiler shall be fired to carry the load?

Prof. Kinealy: We have not yet got down to those details. Here is what the Committee is doing. The Committee agreed that the standard coal, the standard square feet of radiation, and the grate area should be as stated; and then that all the members of the Committee should each separately make out a list stating how many pounds of this standard coal should be burned by boilers having grate areas of different sizes, what should be the efficiency of the standard boiler; and then how many square feet of radiation surface, steam surface and hot water surface this standard boiler should carry. That list would be calculated from the amount of coal and the efficiency; and we are in progress of getting that at present. Each of the members is making out a list of sizes of boilers, giving the amount of coal each boiler will burn, the grate surface, the efficiency, and the radiation. The idea being this: if the conditions under which a boiler was installed were such that it could not burn the amount of coal that was stated in the table for a standard boiler, then the conditions were not standard conditions, and if the boiler

did not do its work it was no fault of the boiler. If, however, the conditions were such that the standard amount of coal could be burned, then the boiler, if it comes up to the standard, would carry a certain amount of direct steam radiation surface.

Mr. Davis: I would ask the professor if he does not think one of the very important things in a house heating boiler should be the number of times that it has to require attention.

Prof. Kinealy: Yes; we have discussed it, but we have not arrived at any conclusion.

Mr. James Mackay: Do I understand the idea is to base the standard entirely upon grate area? Are you not taking some other factors into consideration?

Prof. Kinealy: It is based upon the rate of combustion, square feet of grate area and efficiency.

Mr. James Mackay: Of course that word "efficiency" would take in the question of heating surface?

Prof. Kinealy: Yes.

Mr. James Mackay: I am interested in knowing how you arrive at such a high value to the fuel and such a low transmission of heat from the radiators. I notice that your ratio between steam and water is about 55 per cent., roughly speaking, and your value of coal is about 13,000 B. T. U.'s to the pound. The latter seems a little high, while the other seems a little low. I venture to say there is not a bad boiler in the market. Some are a little more efficient than others, but there is not any of them that you can call a bad boiler.

Prof. Kinealy: Well, to answer your question first as to how we arrived at 13,000 B. T. U. a pound. It was a vote. Each member was asked to say what he considered was the heating power of a standard coal, and the vote, I think, varied from 12,000 to 14,000. The average was 12,800, and we said 13,000 in round numbers. Now, as to the heat emitted from a square foot of radiation surface, with two pounds of steam and 70 degrees air, we took a vote and the votes varied as before. We then took an average and the average was nearly 250, and we said "All right; we will agree on 250."

Prof. Allen: As a member of the Committee my first impressions were that a boiler should be rated on heating surface, the same as we rate power boilers, and that we should distinguish

between fire surface and flue surface. After talking the matter over with the Committee I have changed my views. This method of rating on grate surface accomplishes exactly the same thing and avoids a great many difficulties which the rating on fire and flue surface introduces. But whether you rate on heating or grate surface, the introduction of the factor of efficiency reduces it to an equivalent basis. When you assume a certain amount of coal per square foot of grate and assume the efficiency of boiler and grate you reduce the entire question of rating to the grate surface.

Prof. Kinealy put the following table on the blackboard:

ONE SQUARE FOOT GRATE AREA.

Coal Per Square Foot Per Hour.	Efficiency. Per Cent.	Rating.
2.66	63	87
3.00	50	75
3.00	50	78
3.5	55	100
3.0	60	94

TEN SQUARE FEET GRATE AREA.

Coal Per Square Foot Per Hour.	Efficiency. Per Cent.	Rating.
6.0	66	2059
5.4	60	1685
6.0	65	2028
6.1	63	1900
6.75	63	2205

TWENTY-ONE SQUARE FEET GRATE AREA.

Coal Per Square Foot Per Hour.	Efficiency. Per Cent.	Rating.
7.15	63	4900
7.00	65	5000
7.00	65	4969
6.50	65	4610
7.00	68	5190

Prof. Kinealy: Here are the results of some of the votes. We have here the grate area of the boiler, and I have given you the votes for one square foot, 10 square feet and 21 square feet of grate area. Here are the results of the votes giving the coal burned per square foot of grate surface per hour. We each put the standard amount of coal that should be burned per square foot of grate surface under these conditions; and here is the efficiency that each man used in his rating. For a boiler with ten square feet of grate surface, the coal that the different men thought should be burned per square foot of grate surface is as shown in the table. The efficiency varies from 60 to 66. The rating runs from 1685 to 2205.

The odd figures mean simply this: some of the men gave round numbers and some of the men worked the results out exactly.

For 21 square feet the coal varies from 6.5 to 7.15, the average being about 7. The efficiency varies from 68 per cent. to 63 per cent., the average being along about 65 per cent.; and the rating from 4610 to 5190.

Mr. James Mackay: The efficiency is based upon the value you give in your report?

Prof. Kinealy: The coal, yes, the B. T. U.; 250 per square foot of steam radiation, and two pounds of steam and 70 degrees surrounding air.

Mr. James Mackay: And for water 180?

Prof. Kinealy: For water 160 to 170. We have not put in water here. This is the steam radiation.

Mr. Davis: And right there, what do you mean by efficiency? Do you mean the amount of B. T. U.'s absorbed out of the 13,000 heat units?

Prof. Kinealy: Let me make that clear. If we have 13,000 B. T. U.'s in one pound of coal, and we burn that one pound, we would liberate 13,000 B. T. U.'s. Now, if without any loss, all that heat can be transmitted to the radiator and given off by the radiator, each radiator giving off 250 heat units—in other words, if we could transmit from the furnace to the radiator 100 per cent.—one pound of coal burned in the boiler would carry 52 square feet of radiation for one hour. Now, if we say the efficiency is 60 per cent.—some of us voted 50 and some 60—that means that we think that for every pound of

coal burned we would get the heat given out by 31 square feet of surface.

Let me say this, too. Some of the members based their calculations upon a constant efficiency, the same for a big boiler as for a little boiler. Others gave a low efficiency for a small boiler and a large efficiency for a large boiler. I have purposely mixed these up, so that this man is not the same as that man. (Indicating on table.)

Mr. Davis: But according to that there is much greater efficiency in the larger boilers than in the small ones; that is, the very small ones.

Prof. Kinealy: Yes. To my mind the most interesting part of the vote is the fact that these different members of the committee, located in different parts of the country, should sit down, each one by himself, and come so close as they did. The vote was not hastily taken. As a matter of fact, what we did was this: We first took a vote; then we wrote back and forth about that vote. We found that the men were not voting for the same conditions as to coal and heat emitted per square foot of radiating surface. Then we had a meeting and standardized the thing and took a new vote. We have not yet a full and complete vote of all the members.

Secretary Mackay: I think that should be understood, that the consumption of fuel is the greatest amount that can be burned in any one of these boilers in zero weather. It is not the average consumption at all.

Prof. Kinealy: Oh, no; it is not the average. I do say this: that if the boiler was installed and it could not burn the amount of coal in this table, then the conditions would not be standard conditions. The draft must be such that it can burn this amount of coal. If it burns this amount of coal then it must carry that surface.

Mr. Seward: Professor Kinealy has made the statement that I do not approve of this report, and I would, therefore, like to have the opportunity of telling briefly the reasons why I have not approved it. In the first place, I think the differences that exist between other members of the committee and myself are more with reference to the nature of the work that is expected of this committee on the boiler rating question than to anything else. I believe that this question was referred to the committee

in order that they might bring to a head the discussions that have been held on standards at different times before this body with reference to the existing methods of rating cast iron boilers.

These discussions have been going on before this body from its very first meeting, and in every case they have taken the ground that the existing methods of rating cast iron boilers were unsatisfactory to engineers, and were more or less largely a matter of guesswork. No manufacturer stated how he arrived at his rating, there was no uniformity in results, and as a consequence the engineer and the contractor could not tell whether any given boiler was truly rated or not.

In past years there has been more or less of an insistent demand upon the manufacturer for the amount of heating surface that his boiler contained; the idea of those making such demands being that if they had the measurement of the heating surface and the area of the grate in any particular boiler they could arrive by their own methods at the work it could be expected to do. That demand finally became so insistent that this Society at the 1908 annual meeting authorized the appointment of a committee to investigate the relative value of heating surfaces in cast iron boilers. The committee confined itself to the investigation of heating surface values, and, as Professor Allen has said, those members who started out with the idea that a boiler could be rated by the amount of its heating surface finally came to the conclusion that it was impossible. The committee never presented a formal report, but at the 1909 annual meeting there were submitted the individual ideas of some of the members along this line of arriving at the power of heating boilers by consideration of heating surface values with a recommendation that the investigation should be abandoned; and that some other method of rating might be found and pursued to a conclusion. As a result of the discussion that took place at that meeting the matter of rating cast iron boilers was referred to the Committee on Standards following a resolution suggesting a method which had been outlined in the discussion.

The committee was to establish a standard method for rating cast iron boilers based on coal consumed per square foot of grate per hour and the efficiency of the boiler. I think we should arrive, as it states, at a standard method for rating, and not a standard rating, in other words, broadly speaking, I should say

that what was expected and what was desired by the membership of this Society was some standard or uniform method of arriving at and expressing the power of cast iron boilers for heating purposes, and not a so-called standard rating that would be applicable only as a fixed level by which all boilers would be measured up or down. The differences existing in the committee are based, in my judgment, entirely upon that one point. With such an understanding of the requirements I could not approve of this tentative report, because it deals with assumed efficiencies and then goes into a recommendation whereby a scheme is to be worked out to provide for those boilers which are above and possibly below this assumed efficiency.

About five years ago the boiler manufacturers, who were then very closely associated for the advancement of their own ideas, appreciated the necessity of some more uniform and desirable method of expressing the power of the boilers which they manufactured, and as might be imagined, in a commercial body of that kind, they came to the conclusion that if they could hit upon a uniform rating for all boilers of a given size it would do away with all the evils that then existed. That feeling was so strong that it resulted in the appointment of a committee to work out some scheme whereby the boilers of these various manufacturers could all be rated on the same basis. That committee worked on the subject for some considerable time, and the result of their deliberations was that a boiler should be measured by its outside dimensions, by the height of its water line, and by some other calculations, all of which are on record before this Society in a paper presented by Mr. Blackmore five years ago. The manufacturers, when that committee reported, thought so well of the scheme that they adopted it forthwith, and as a consequence all boilers made by members of the association at that time were rated according to the formula adopted. The scheme they worked out took into consideration, in my estimation, more of the vital considerations that enter into the real power and rating of a heating boiler than does the scheme now proposed. It was based, more or less intelligently, upon the amount of heating surface in the boiler and by its general dimensions—not by the size of the grate—and an estimate of the efficiency.

The manufacturers' scheme was fruitful in this respect; that

it prevented anybody from building a freak boiler to obtain a high rating. Now, it is true of the scheme outlined in this report that if this Society will resolve itself into a court of appeals the manufacturers might possibly be prevented from building freak boilers. My judgment, however, is that if the Society gives out a standard, so called, as to what a boiler with a given size grate should be rated to do, you are going to find manufacturers who will build boilers having the only part of the specifications mentioned, which is the grate, but which will not come anywhere near doing the work that this standard calls for, resulting in endless litigation and dispute.

Now, the element comes in that it might be inadvisable for the manufacturer to claim anything for a boiler which it will not perform. But he can do as he does to-day—state his conditions, give a capacity rating, and then notify the trade, more or less completely, as to what they shall provide for in using the rating.

I believe that what we want is some body, and preferably this body, to standardize conditions under which heating boilers may be expected to operate. I believe that we should standardize the rate of combustion, and that we should express it in terms of pounds of coal per square feet of grate per hour, because that is a unit that everybody has become educated to and is familiar with. I also believe that we could standardize the time that the boiler should be run with one firing, and that we should divide the boilers into classes by a sort of grade with reference to the character of building in which they are likely to be installed. By fixing the time which each class of boiler shall run on one firing, we will automatically change the rate of combustion, providing we determine a standard depth of fuel for one charge and which it seems possible to burn on the grate of boilers under consideration with ordinary draft condition and attendance. We should also define a standard code under which heating boilers can be tested to determine their evaporating efficiency. I think when all the operating conditions are standardized in code for test and given to our members and the public at large that the manufacturer will accept them; and if he has not already tested his boiler according to the code laid down by this Society will do so, and determine his rating by the actual performance of the boiler under the standard conditions.

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Now, it seems to me that when all this has been accomplished the members of this Society, the architects and the trade at large will have all the information they need to enable them to apply a boiler rating, not only under the published standard conditions, but under conditions they might be confronted with in the particular building in which they were to install the plant. It seems to be decidedly unwise for us to set up any rating based on an assumed efficiency and then get this Society into trouble by entering into disputes which will continually arise between boiler manufacturers and their customers. I think it is entirely beyond the province of this Society to go into any work of this kind, and it appears to be unnecessary, as all we are after will be accomplished by the other method. I think the procedure I have outlined is what the engineer wants, what the contractor wants and what the architect wants. And it is for these reasons that I am opposed to this idea of voting or making any calculations based upon assumed efficiencies. It is so easy and simple to test cast iron boilers and make calculations based upon their actual performance under the standard conditions that it seems absurd, in my estimation, in this enlightened age, to offer our members assumptions which mean absolutely nothing, and do not represent actual performance. I do not believe that you can arrive at the average capacity of cast iron boilers by a committee vote, therefore, the only right and logical way is for each manufacturer to test his boilers under the standard conditions this Society lays down, make his ratings according to results obtained and so publish them to the trade at large.

I do not agree with Professor Kinealy, as he deals with boiler construction instead of boiler rating. This Society has not before it any question of boiler construction. Furthermore it has nothing to do with boiler construction in my estimation. Its function so far as brought out is in regard to a uniform method of rating. Mr. Blackmore read the report of his committee this afternoon and one of the questions he asked during his investigations was: "Do you place any reliance on the ratings given by boiler makers in their catalogues?" If I remember correctly 70 per cent. of them said they did. If the steamfitter and the buyer of the boiler do rely upon the maker's rating, then I think this Society should set a standard on which such rating can be based. You can make a cast iron boiler in many differ-

ent ways. When a contractor buys a boiler the assumption is that his engineer will install it on a basis suggested by specified tests and conditions or make allowances to suit the case. For instance, the manufacturer may say his boiler will develop 60 per cent. efficiency on a consumption of five pounds of coal per square foot of grate per hour and rate it accordingly. With such standard rating he assumes no responsibility for the boiler other than for tested efficiency, and would have nothing to do with conditions of installation.

I have a record here of some of the things that have been said before this Society on heating boiler ratings, and it covers fifty typewritten pages. This subject has been discussed here time without end. It has been brought up at almost every meeting of this Society. One of the members at the 1895 meeting stated that the boiler manufacturer's rating could not be relied upon, and this Society should set a standard for such ratings. There is $25,000,000 invested in the manufacture of cast iron boilers, and there are very close to 100,000 of them being used in this country every year. The people who make these boilers know what they are doing, and the assumption is that the people who are using them know what they want. If the people who are using them will standardize the normal operating conditions the manufacturers will build boilers to suit. I think that this matter ought to be brought to a head and either dropped or a standard method created. It is a disturbing factor. It has been published so much in the papers, and the fact that it is brought up and discussed on the floor of this Society has received more or less recognition, so that many people have come to believe that the manufacturers do not know how to rate their boilers. The trouble is each manufacturer has a standard of his own, but it has not occurred to us that possibly he does not care to state his conditions.

Now, if this Society has any normal operating conditions to suggest let us define them. Let us know what they are. I do not know of a better body to set the standard than this Society. It is composed of engineers who cover designing as well as installation. If we do not know what is the average coal consumption to be expected in domestic heating plants I do not know who does. Certainly the manufacturer has nothing to do with it. The best way would be for this Society to define a

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standard coal consumption in pounds per square foot of grate per hour. When you get the manufacturer's efficiency for his boiler then you can determine his rating, and you can apply that rating to suit any particular installation.

I hope something will be done with this question. It has gone too far to let it alone. If this Society is not big enough to handle the proposition, then I think it ought to be turned over to some other body that is. (Applause.)

Prof. Carpenter: I think I have arrived at very much the same conclusions as those presented by Mr. Seward. Why should we not take things as they are, take an actual efficiency, and not an assumed efficiency? The methods for testing coal efficiency have been determined; they are well known; it costs very little to get them; it costs very little, in fact, to find out the heat value of a pound of coal. Now, why should we assume that a pound of coal contains 13,000 B. T. U.'s? If it may contain 10,000 or 15,000, why not send it to the laboratory and for a five or ten-dollar bill then we can find out exactly what that coal contains and have something accurate. The same way with the efficiency. It seems to me the efficiency should not be an assumed but an actual efficiency. Otherwise than this I believe that the basis of work of the committee is correct. I hope that it will be continued and I hope that we shall have something before us which will be lasting.

The table which Prof. Kinealy has put upon the board it seems to me is a very interesting one. It shows that the assumptions made by engineers and experts respecting the efficiency of these different boilers is in a remarkable agreement. It is probably very close to the truth, and I think it would be well to have all that information in the report, but I think it should be put in as information and not as an absolute statement, that such and such boilers should have such efficiency under the ordinary conditions of operation.

Mr. Davis: I would like to ask Prof. Kinealy, on taking a boiler of, say, ten feet grate area, suppose some reputable manufacturer, or a number of them, demonstrated the fact that they could burn seven pounds of fuel per square foot per hour, or another demonstrated positively that he could burn eight: would you give them the same relative efficiency for the coal consumed?

Prof. Kinealy: I can only answer that question for myself. I cannot answer for the other members of the committee. I should not give him the same efficiency. The coal prescribed per hour means simply that a house-owner must provide a chimney and conditions such that he can burn that amount of coal. Now, if the house-owner provides a chimney whereby he can burn eight or nine or ten pounds of coal per square foot of grate per hour, of course that boiler will carry more surface than that given in the table.

Mr. Davis: That is just the question I am bringing up. Will you give him an efficiency according to the coal consumed per square foot?

Prof. Kinealy: I would not give him the same efficiency, I would give him a higher rating. That is to say, suppose we take at 6 pounds; the efficiency is 65 per cent. (Referring to table.) That would give a rating of about 2,000. Now, suppose you put that boiler in so that it burned 8 pounds—one-third more. Now the efficiency would not be quite 65; it might be 67½ or it might be 63 or 64; and you would get nearly one-third more capacity. In other words, you would get about 2,700 square feet. If you burn more coal you get a higher rating.

Mr. May: May I ask, Prof. Kinealy, that if it should be shown that at a rate of 6 pounds you would only get an efficiency of 65 per cent., and it should also be shown that if you burned at a rate of 8 pounds you would get more heat per pound of coal, what would the answer be then? Now, at 6 pounds, the boiler will not show more than 65 per cent. efficiency, but if run at the 8-pound rate the efficiency or the heat units developed per pound of fuel goes up, and, according to you, the efficiency drops down. If it could be shown that it went up what would be your idea?

Prof. Kinealy: The contractor puts in his boiler and if he burns six pounds of coal it is standard conditions. He does not have to furnish conditions to burn eight pounds.

Mr. James Mackay: I do not understand that this is laid down as an arbitrary method of rating a boiler. It is simply a suggestion on the part of the committee as to a method that may be employed. The amounts of fuel burned per square foot of grate per hour may be increased if the manufacturer so

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elects. The factor of efficiency is, as I understand it, to be determined by actual tests. I do not think they assume or pretend to assume a factor of efficiency for any particular boiler. I think they intend that they shall be established by actual tests, as Mr. Seward suggests. The committee must be careful regarding the ratio of fuel consumption; few manufacturers rate boilers based on a higher rate of combustion than is given by the committee, and some makers use a much lower ratio; all manufacturers have records of elaborate tests which they have made to determine the capacity of their boilers; they know how much water their boilers will evaporate per pound of coal consumed, and anyone interested can usually obtain this information.

President Snow: I would like to say, and Prof. Kinealy can correct me, that what the committee was driving at was to get any opinions, based on as extended experience as possible, as to what those people who gave the opinions considered fair average ratings under ordinary working conditions. It is the function of the engineer to determine, in view of the class of building in which the boiler is to be placed and the kind of attention it will receive, what the rate of combustion should be. That is the province of the engineer. But it was hoped, as I expressed it in the committee meeting at Niagara Falls, to establish, as they say in civil engineering, a datum plane from which these capacities could be measured up or measured down, as the case might be. That may clear up the situation a little. It was hoped that these estimates, or votes, as Prof. Kinealy has termed them, would represent fair average practice, and when brought into final shape be of assistance to the contractor or to the layman in making a selection or know what he ought reasonably to expect to get out of a boiler in capacity under average working conditions.

Mr. Macon: I should like to suggest that the chairman of the committee explain a little more about what the effect would be if the Society saw fit to adopt this standard rating. Now you have, as I understand it, explained how the heating contractor can tell how much radiation he ought easily to supply with a given sized grate. If the Society did adopt this standard, would you expect that this standard would be published in boiler catalogues? Would you expect that the steam heating fraternity

would generally become familiar with the standard? In other words, what would be the effect if the thing were adopted?

Prof. Kinealy: The effect of a standard boiler rating seems to be somewhat the same as the effect on boilers of engines when the American Society of Mechanical Engineers adopted thirty pounds of steam under certain conditions of temperature of feed water and a certain pressure of steam, as one horsepower. Many engines use less than thirty pounds of steam per hour per horsepower, many use more; yet we all, in figuring horsepower, think of thirty pounds of steam per hour. Now, in the same way, it seems to me, we will do if there is a standard rating for cast-iron boilers. We will think of a boiler having a grate area of ten square feet, as carrying about 2,000 feet of direct steam surface, when the coal burned in the boiler has a heating power of 13,000. The committee had, as Mr. Mackay said, to consider the contractor and the boiler manufacturer. We also had to consider the house-owner. The standard rate of combustion was, I think, voted on somewhat with the idea that the house-owner should not be expected to supply a mechanical draft system in order to heat his building, but he should supply enough draft to burn a reasonable amount of coal. Not only that, but in order to protect the contractor and the boiler manufacturer the house-owner must use good coal, a standard coal. A coal having a heating power of 8,000 or 9,000 B. T. U.'s per pound would not be what the committee thought would be standard coal. The committee agreed that the standard coal should be one having 13,000 heat units per pound of dry coal. Then the contractor is protected, in that if the house-owner uses coal of standard quality and the contractor puts the boiler in with a chimney so that he will burn a given rate of coal per square foot of grate surface per hour, the boiler must be made to carry the stated amount of surface. In that way the house-owner, the contractor and the boiler manufacturer will be protected. I am sure that is the reasoning of the members of the committee. It was the way in which I reasoned and it was the way in which others reasoned, because they said so to me.

Mr. Feldman: I would like to ask the professor how he got the efficiency. Divide 13,000 by 250 and it looks to me as if it would have to be an efficient boiler that would have that effi-

ciency between the coal and the radiator, which includes the piping. The latter should be taken into consideration, whether the piping is small or large or whether the piping is covered.

The second point I had in mind was the figures in which the dissenting votes of the committee were expressed. I always have difficulty in selecting a cast-iron boiler. Two boilers may have the same grate surface and one may be about a foot shorter than the other, or the heating surface may be higher. The rating will be the same in the catalogues. The difficulty will be to go to an arbitrary committee every time to find out whether we are getting results. How can a contractor select a boiler without any other criterion to go by than the heating surface or grate surface? I had a case where a contractor came around to my place and offered me a different boiler than the one I specified. He said, "The grate area was the same, the rating was the same." But I found from the catalogue it was about a foot lower than the other one. I did not want to take chances and I didn't allow the substitution.

Secretary Mackay: As Mr. Seward says, this question has been touched on ever since the time the Society was first organized. But we have all this information as to what the different manufacturers have done, it is all before us, and we also have the information that some manufacturers have built boilers and rated them for a certain number of square feet of radiation and have lately reduced their figures 33 per cent. We have other cases where they have increased them 50 per cent. We have all the different changes that they have made, and still at the 1908 meeting the question seemed to be as far from being solved as ever. And it was brought out there that it would be a desirable thing for this Society to establish a standard method of rating boilers. It was stated that one boiler, with three different names on the front, had three different sets of ratings. It was stated in our proceedings that there were other cases where tests had been made of boilers that could develop a certain efficiency in a factory building, with a flue four feet square, a new and clean boiler, with experienced firemen firing, and then did not develop within 50 per cent. of that under the average conditions of the house-owner. Then a committee was appointed to go into this question of rating. This committee brought in a report at the last meeting, and on the strength of the report the Society voted

that the matter be referred to the Committee on Standards and that they work in conjunction with the other committee to form a rating for cast-iron boilers. It seems to be a necessity; if in the fifteen years of the Society's existence, we have not been able by the different methods brought in to accomplish anything in the way of a satisfactory rating, then it seems to have been the right thing to refer it to the Committee on Standards. And while this is largely, as I understand it, discussion for information to-day, the indication is that the Committee on Standards will continue to work and bring in a final report at the next annual meeting, as they are instructed to do, and I think that whatever report this committee brings in, it should be without regard to anything except that particular subject from an engineering standpoint, not the manufacturer or what his goods are to-day or anything of that sort. It has been stated that as engineers we are not to dictate to a man as to how he shall construct his boiler. When the Society was organized away back fifteen or sixteen years ago the second object of the Society was: "Improvement in the mechanical construction of the various apparatus used for heating and ventilation." We should consider that as engineers and formulate our report regardless of whether one or a hundred manufacturers have to work up or work down to that standard.

Mr. Seward: I would like to say in conclusion that I have followed very closely the objections that different members have presented to this assumed efficiency scheme as outlined on the blackboard, and I believe most emphatically that every one of the objections will be overcome if this Society standardizes operating conditions for house heating boilers and then suggests that the power of the boiler be determined by the manufacturer after actual test according to a standard code, which this committee will lay down; each manufacturer also to rate his boiler by its actual efficiency under the standard operating conditions and state in his catalogues the efficiency on which he bases his ratings. Now, if the engineer is interested in the matter he can, by the manufacturer's catalogue, determine whether the conditions available are the same as those under which the manufacturer rates. It is the manufacturer's efficiency which I think ultimately will be guaranteed along these lines, as he will know exactly what he is doing; and the archi-

tects and engineers will be relieved because they know the standard operating conditions which are required. It seems to me the Society is going to solve this problem satisfactorily to its own membership at least, if it brings about a statement in the manufacturer's catalogue that he rates his boiler under the operating conditions that this Society has decided are normal after testing his boiler according to the standard code. Now, if we can accomplish all this and do it without involving ourselves in any of the disputes that might arise or any of the objections that have been presented, is not that better than going ahead and adopting something by vote or estimate and then adjusting the disputes as best we can?

On motion the session was adjourned.

Afternoon Session.

The meeting was called to order at 2.55 P.M.

President Snow: Gentlemen, we will continue our meeting with the reports of committees. I believe Mr. Chew, representing Mr. Harrison, of the Legislative Committee of New York, has a report which he will read.

Mr. Chew read the report.

"Since the last annual meeting of this Society there has been little progress in the efforts to prevent the repeal of Section 86 of the factory law regarding the ventilation of loft buildings used for factory purposes. A letter was framed and sent to Governor Hughes, to the President of the Senate and to the Speaker of the Assembly. It is proposed to send circular letters to the members of this Society, urging them to take the matter up with their State Senator and assemblyman. It is hoped that at the next annual meeting we may have something definite to report. In the meantime it may be of interest to note that in the State of Illinois, Senate Bill 385 has been enacted and become a law July 1, 1909. Section 11 of this bill reads as follows:

" 'Sec. 11. In every factory, mercantile establishment, mill or workshop, where one or more persons are employed, adequate measures shall be taken for securing and maintaining a reasonable, and, as far as possible, equable temperature, consistent with the reasonable requirements of the manufacturing process.

No unnecessary humidity which would jeopardize the health of the employees shall be permitted.'

"This is as complete a bill as has been passed by any of the States so far. The last sentence of Clause 11, 'no unnecessary humidity which would jeopardize the health of employees shall be permitted,' certainly means dehumidification under some circumstances, but leaves open the question of the limits within which humidity does jeopardize the health, and the burden of proof would seem to rest in the factory inspector. There is no doubt that in factories similar to paper mills, where the cooling by contact of humid air with outside walls and roofs results in precipitation which damages the product of the mill, there should be little difficulty in enforcing the law, since its enforcement is to benefit the output of the mill. However, where the output of factory is of a nature not affected by humidity or moisture this might not be true. In England, where the climate is naturally very humid at times, it was found necessary to pass laws limiting the allowable humidity in cotton mills since the mill owners were prone to carry it to as high a point as possible to facilitate the weaving of cotton cloth. Since it is a fact that the effect of humidity on the vital forces of the human body varies with the temperature of the air, it would seem that some definite relation of relative humidity to temperature should be established, and there appears to be some need for the Society to obtain what data are available along this line."

On motion the report was accepted.

Mr. Whitten: I do not know whether what I have to say is pertinent, but I have some information for the Committee on Compulsory Legislation which I have received recently—I think the Society ought to have it now—and that is in regard to proposed legislation in the State of Massachusetts. Compulsory legislation in the State of Massachusetts has been practically inoperative because of a law passed giving inspection on the reports on bad ventilation to the State Board of Health, and, apparently, provided the reports were made, that was the end of it. The district police have had up to that time authority in those matters. In order to obviate the clash between the State Board of Health and the Massachusetts district police this legislation is proposed:

Section 105. Every public building and every school house

shall be kept clean and free from effluvia arising from any drain, privy or nuisance, shall be provided with a sufficient number of proper water closets, earth closets, or privies, and shall be ventilated in such a manner that the air shall not become so impure as to be injurious to health. If it appears to an inspector of factories and public buildings that further or different sanitary, ventilating or heating provisions are required in any public building or school house, in order to conform to the requirements of this section, and that such requirements can be provided without unreasonable expense, he may issue a written order to the proper person or authority, directing such sanitary, ventilating or heating provisions to be provided. A school committee, public officer, or person who has charge of, owns, or leases any such public building or school house, who neglects for four weeks to comply with the order of such inspector shall be punished by a fine of not more than one hundred dollars. Whoever is aggrieved by the order of an inspector, issued as herein provided and relating to a public building or school house, may appeal to a judge of the superior court, as provided in chapter four hundred and eighty-seven of the acts of the year nineteen hundred and eight. The state inspectors of health or such other officers as the State Board of health may from time to time appoint shall make such examinations of school buildings as in the opinion of said board the protection of the health of the pupils may require. The provisions of this section shall be enforced by the state inspectors of factories and public buildings.

There was at my last information practically no legislation in force in Massachusetts except the first initial inspection of a public building by the state police. After that they may shut down their vents and nothing further be done. I wanted to bring this before the Society. It was thought it might be put upon the record for the information of the Society.

Mr. Hale: I move that the article read by Mr. Whitten be placed upon the record of the Society and a copy be sent to the Committee on Compulsory Legislation so they may have the record.

Prof. J. D. Hoffman: Just for information, I suppose there are not many of you that know that Indiana had a law that they came very near passing the last legislature. It went to the third reading and it was knocked out.

Prof. John R. Allen then read a paper on "The Effect of Painting Radiating Surfaces," and Mr. Macon read a paper by Mr. B. S. Harrison on "The Heating and Ventilating System of Finney Chapel, Oberlin College, Oberlin, O." The paper was briefly discussed.

Secretary Mackay read a paper on "Safeguarding Our Profession," which was discussed by Mr. Whitten.

President Snow: The first topic for discussion on our list is No. 1: "The relation of fan pressure and peripheral velocity in public building heating systems, operating at a velocity of 1500 feet per minute."

If there are no remarks on this topic for discussion we will pass on to No. 2: "The quality of the air with relation to CO_2 and humidity in school-rooms heated by fan blast systems, with no provision for washing and humidifying the air."

There being no discussion, Topic No. 3: "The minimum fee for professional services," was taken up and discussed by Secretary Mackay.

Topics No. 4, "The fire risk in connection with heating and ventilating systems," and No. 5, "Legal regulations for the installation of heating systems for residences," were discussed by several members.

Topic No. 6, "The use of aprons in front of direct-indirect radiators," received no discussion.

(On motion the session adjourned until evening.)

Thursday Evening Session.

The meeting was called to order at 8.30 P.M. by President Snow.

President Snow: Ladies and gentlemen: We have with us this evening Dr. Hurty, Health Commissioner of the State of Indiana, a gentleman who has made a very broad study of the subject of tuberculosis, the gentleman in whose charge is the ventilation of the school buildings of this state, and through whose hands all plans must pass for approval before the heating and ventilating systems are installed. He is very well known throughout this section and has much of interest to say to our

Society, to which we shall be pleased to listen. I have pleasure in introducing Dr. Hurty. (Applause.)

Dr. Hurty spoke, in part, as follows:

I am glad of the opportunity to talk upon my favorite subject to a body of life-savers like yourselves; for you certainly are life-savers, engaged as you are in the matter of presenting to the people in their houses the first essential of life, namely, air.

As an introduction to what I have to say I want to read you an utterance made by David Starr Jordan. It is an utterance in regard to little children; and in ventilating school-houses we are looking after little children. David Starr Jordan, the great educator and scientist, says: "There is nothing in the world so important as little children, nothing so interesting. If ever you wish to go in for philanthropy, if ever you wish to be of any use in the world, do something for children. If ever you yearn to be truly wise, study children. We can grasp the sword, bandage the wounded, imprison the criminal, heal the sick and bury the dead, but there is always the chance that you can save the child. If the great army of philanthropists ever has any inspiration for working out our race's salvation it will be because a little child has led them."

I submit that to you as a very sublime sentiment, and absolutely true. You gentlemen are engaged, I repeat, in life-saving. Of course you make a business of it, and that is right. You derive a profit from it. Life-savers should have a profit as much as those who clothe us or those who furnish us transportation, or those who render any other good service. And this subject, I say, of ventilation cannot be overstated in its very, very great importance.

School hygiene, the care of the child, is a question of far greater importance to the American people to-day than the tariff that we are blustering and fuming and fussing so much about; more important than the Panama Canal; it is more important to the people of this country or any country than their armies and their navies. What are we here for in this world, placed here by a beneficent Creator? For the sole purpose of perpetuating the race and perpetuating it properly. We are here to be parents, to raise families and to raise them properly and then pass away.

So school hygiene, then, after the child leaves the mother, is the greatest of all subjects that we have to teach or to handle. Gentlemen, that is obvious. And you are engaged in a branch, in an important branch, and the most important, of school hygiene—of all hygiene—the furnishing of an abundance of pure air, the first requisite of life, that which is necessary to make a good animal; and if the child is not a good animal he cannot be anything else that is good; for being a good animal is at the bottom of all his possible goodness. How can you make a moral, strong, useful, intelligent, educated man or woman out of a sickly, puny child? And if you bring sickness and puniness upon a child through surrounding him with evil conditions, unsanitary conditions, you have done a wicked thing, you have done an extravagant thing, you have done an ignorant thing, you have done a stupid thing.

And yet, gentlemen, that is being done all over the State of Indiana. Ignorance and stupidity everywhere are surrounding the school children with conditions which kill them. If we killed them outright it would not be so bad, but it brings upon them lingering death. In 1908 1,339 school children died out of the schools of Indiana—1,339 right out of the schools. We find by close investigation of those deaths that eighty per cent. of those children were killed in the schools, principally from lack of air. That is literally true, gentlemen, in this civilized day. By a statistical calculation it is found that there are 20,000 school children out of the 500,000 in Indiana that have tuberculosis.

Now, some may scoff at this and say this is all nonsense, this estimate. Therefore we will make a concession and say cut it in two and say 10,000; cut it in two again and say 5,000. Five thousand children in Indiana with incipient tuberculosis. How many of them wlll be cured? Because that is a curable disease if taken in its incipiency. A number of them will be discovered run down in health, losing strength, becoming languid, their lips becoming pale, they cry out in their sleep and nervousness comes upon them, and parents will realize it and take them to the doctor and the doctor will say: "This child needs to be taken away from its present environment." The child is taken to the seashore or country, if the parents are so situated that they can do it, and the child recovers and it is

reprieved from the sentence of death, and that child has recovered from tuberculosis. And that is happening all the time. So a certain number will be reprieved. Let us say, for calculation, that 2,000 will be thus reprieved, and that is about all. The other 3,000 must die—killed in school. They will not all die in one year, but killed in the school; for you take them out of the schools and they will get well very frequently; put them back and they are sick again.

Now where is the common sense, where is the business, of surrounding children with conditions that affect their efficiency in study, that take from them their health, that take from them their lives? Well, Indiana is doing that very thing, and business men are doing it. Everywhere over the state where I travel—and I am traveling continually, meeting school officials and town officials and city officials, and trying to raise up these conditions—you find men determined to keep up these conditions which bring ill health, disease, death and inefficiency to those they love. And they call it business. It is not business. It is gross ignorance, it is stupidity; and the question, gentlemen, is, how we can overcome this stupidity. We can only overcome it through education; that is the best way. And how can we educate? The ordinary process of education is very, very slow indeed.

Education is a very slow process, but it can be quickened by passing compulsory statutes that will compel people to do things that they would not otherwise do. We recognized that last year when we passed our laws for compulsory education. But up to this date we have no law requiring that the children being educated shall be surrounded with healthful conditions, which is the very first principle of education. Why are we so slow in that? Now, if we could get a statute passed that would compel people not only to send their children to school—and you know a great many of them would not do it unless they were compelled to—but would compel them to build proper schools, oh, what an advance it would be. It would be strength and happiness and money in our pockets right away.

Now such an effort was made before our last legislature. A bill was carefully drawn that required sanitary schools hereafter to be built, and more than that, it required medical school inspection. I have a copy of that bill before me. I wrote it

myself. It passed the Senate without the least bit of trouble, it passed the House the third reading, and within four members of the hundred in that House were promised to vote for it, and yet it did not pass—a very curious situation. It was a political matter—nasty, filthy, rotten politics, which governs us so frequently. There is a copy of the bill. It is entitled "Senate Bill No. 15. A bill for an act entitled An Act to protect and conserve the health and lives of school children by providing for their medical inspection, by providing healthful schoolhouses and requiring the teaching of hygiene."

President Snow: It is hard for your President to express in any fitting manner, voicing your sentiments, his appreciation of this address by Dr. Hurty. I feel that we have been touched, we have been appalled by the statements that have been made. At the same time we have been enthused to proceed along the lines we have had pointed out for advancing or benefiting or promoting compulsory legislation in all public buildings in accordance with the standards that the Doctor has established. I think, however, we have been impressed more clearly with our duties and with our opportunities in this respect. I think it is safe to state that every one of us has seen school buildings exactly as Dr. Hurty has described, and know that they exist today, and know of the necessity for these compulsory ventilation laws. We have that work of public welfare which it seems to me must yield the greatest rewards and the highest satisfaction to this Society. I wish to thank Dr. Hurty most heartily on behalf of the Society for his very able address on this subject, and I think I can assure him that it will do good in promoting the things to which he is devoting the major part of his life and his time.

Mr. Weinshank: In addition to the expression of gratitude to Dr. Hurty for his lecture to-night I make a motion that a vote of thanks be expressed to Dr. Hurty for his lecture, as an expression of the thanks of the Society.

President Snow: The motion has been made and seconded, which the chair has pleasure in putting, that a vote of thanks of the Society be tendered to Dr. Hurty for his address and that it be spread upon the minutes.

(Carried unanimously by a rising vote.)

XUM

Mr. Weinshank: I would like to ask Dr. Hurty whether or not he has in view the subject of factory ventilation.

Dr. Hurty: Yes, we have a factory law, but it is not efficient. It is not what we should have. It simply says that ventilation shall be provided, but does not say specifically how much. It is very meager, and that too should be amended. We have that in view.

(On motion the meeting adjourned.)

Friday Morning Session.

Indianapolis, Ind., July 16, 1909.

The meeting was called to order at 10.45 A.M. by President Snow.

President Snow: I will request Mr. Feldman to read his paper on "A Combination Ventilating, Heating and Cooling Plant in a Bank Building."

Mr. Feldman read the paper which was discussed by Messrs. Davis and Macon.

The following topics were then briefly discussed:

No. 7.—The average temperature of the air from registers in furnace heating systems with inside air supply.

No. 8.—The proportional reduction in velocity of air flow and loss of temperature in a rectangular flue of 4 x 12 inches, compared with an 8-inch round flue, both working on gravity with an initial temperature of 140 degrees.

No. 9.—The requirements as regards tightness that should be met where a vacuum house heating system is to be installed.

No. 10.—The guarantee that should be given as to the amount of steam that may pass into the returns in a vacuum return line system of heating.

(The session then adjourned until the afternoon.)

Friday Afternoon Session.

The meeting was called to order at 2.30 P.M. by President Snow.

A paper was read by Mr. W. H. Whitten: "Examples of Wind Effects on Ventilation and Heating."

The paper was discussed by Messrs. Donnelly, Chew and Prof. Carpenter.

The following topics were presented, but no discussion followed:

No. 11.—The relative value of window ventilators and coil heated aspirating flues for school buildings heated by direct radiators.

No. 12.—The effect on the ventilation of office buildings heated by direct radiators where weather strips are used on the windows.

No. 13.—The additional direct radiation necessary to provide for ventilation in the rooms of residences, particularly bath rooms.

No. 14.—The velocities of flow secured in hot water heating systems at different temperatures and heads.

Mr. Donnelly: I would like to make a motion for the appointment of a committee or two before we adjourn. I think the investigations of committees along the line of air washers and fan blast work and these other things have been producing wonderful results, and there are two other topics which we want committees on; and unless we can frame good names for the two we cannot distinguish them very well. My motion is that we appoint a special committee to gather data in regard to appliances and methods of operation of mechanical vacuum systems, and another committee on atmospheric vacuum systems. I apply these two classes of systems, one covering the vacuum return line, and the vacuum air line system, probably, to the other, which has come to be known as the atmospheric vacuum system. I do not think we can do any better work in the Society than in properly distinguishing names for these two systems. Sometimes both of them are confused with vacuum cleaning systems, and there is a great deal of confusion between the two in the trade.

I make a motion for the appointment of those two committees for collecting data, and hope it will prevail.

The motion was seconded and carried.

(On motion the meeting adjourned.)

List of Members and Guests present at the Semi-Annual Meeting, July 15 and 16, 1909.

MEMBERS.

Allen, John R.
Armagnac, A. S.
Bacon, J. H., Jr.
Baker, W. A.
Boylston, John
Carpenter, R. C.
Chew, Frank K.
Cripps, A. G.
Davis, Jas. H.
Donnelly, Jas.
Feldman, A. M.
Fenstermaker, Sidney
Gifford, Byron T.
Gillham, C. A.
Graham, Jos.
Grier, Wm.
Hale, John F.
Harvey, Andre.
Hayes, Jos G.
Hofft, F. B.
Hoffman, Geo. D.
Hoffman, J. D.
Johnson, W. H.
Kauffman, Sam'l
Kehm, August
Kerr, A. W.
Kellogg, A. T.
Kinealy, J. H.
Mackay, James
Mackay, W. M.
Macon, W. W.
May, E. A.
McGuire, F. W.
Natkin, Benj.
Ryan, Edw. J.
Seward, P. H.
Snow, Wm. G.
Stackhouse, R. M.
Tait, Thos.
Weinshank, Theo.
Whitten, H. W.
Wolf, Wm. C.

GUESTS.

Ascher, L. K.
Benjamin, O. P.
Bradley, R. A.
Braemer, W. G.
Brewster, J. H.
Brown, J. P.
Bushnell, H. C.
Conrad, W. H.
Denison, T. H.
Dillon, H. L.
Farquhar, M. J.
Gaelting, F. B.
Gilchrist, J. M.
Haldeman, R. E.
Harmon, J. F.
Hurty, J. W.
Johnson, J. W.
Johnston, Burt R.
Keegan, T. E.
Kirkhoff, G. F.
McCarthy, C. F.
Moyer, J. A.
Phegley, F. P.
Powell, Edw.
Raber, B. F.
Schardein, W. F.
Sheahan, A. F.
Shorb, W. A.
Sparks, J. L.
Straw, L. W.
Turner, R. C.
Weinland, A. H.
Werkhoff, A. E.
Wocher, H. J.
Wood, Geo. W.
Zellweger, John.

CCIII.

THE EFFECT OF PAINTING RADIATING SURFACES.

BY JOHN R. ALLEN.

(Member of the Society.)

The experiments described in this paper were conducted in the Experimental Laboratory of the University of Michigan. The apparatus used for testing the radiators has been described previously in connection with the discussion of a paper presented before the Society. In conducting the experiments to determine the effect of painting upon the heat transmission through radiators, two flat cast iron boxes were used in place of the radiators.

DESCRIPTION OF THE APPARATUS.

The apparatus used may be described as follows: The two cast iron boxes were placed near the inside wall of the room in the same relative position to the outside wall surface. On the floor below steam was admitted to a chamber through a reducing pressure valve. From this chamber, with nearly equal lengths of pipe, steam is conducted to the radiating surfaces. This piping is heavily covered with hair felt. Condensation from the two radiating surfaces is conducted to two chambers which are used to accumulate the condensation. These chambers are provided with gauge glasses so that the condensation in the chambers may be maintained at a uniform level. The condensation is drawn through valves from these chambers to the cooling coils on the floor below. The condensation after being cooled so as to avoid steaming, is weighed in tubs. Valves below the chambers are set so as to obtain as nearly as possible a uniform discharge of water from the chambers. The usual period of time during which tests are conducted was three hours, and before a

test was accepted as correct the condensation for two successive hours was compared and a test was not considered satisfactory if the condensation for two successive hours varied more than 2 per cent.

METHOD OF MAKING THE TESTS.

The method used in determining the effect of painting the radiating surfaces was to leave one radiator unpainted and paint the other. The heat loss from both radiators was determined in each test, and the ratio of the heat loss of the painted to the unpainted radiator was termed the efficiency. During the tests, readings were taken of the temperature of the steam entering the radiator, of the temperature of the water leaving the radiator, of the steam pressure, of the temperature of the outside air; the moisture condition was determined by a wet and dry bulb thermometer, and the temperature of the room was taken in three different places. Thermometers subject to radiant heat had their bulbs protected with paper cones so as to avoid error. The actual surface of the radiators used was obtained by careful measurements.

READINGS TAKEN.

The actual surface of radiator No. 1 was 9.99 square feet; of radiator No. 2 the actual surface was 9.9 square feet. The steam pressure maintained throughout the entire test was 4¼ pounds gauge. All readings given in the following table (page 233) of results are corrected readings. Corrections were made for steam gauge and thermometers both before and after the test. The table gives the principal results obtained from these tests.

Column 10 of the table headed "efficiency" gives the heat transmission of radiator No. 2 as compared with radiator No. 1, which has been assumed as a standard and was left unpainted during the test. In comparing the effect of the various coats, the efficiency, as given in column 10, has been taken as a basis of comparison. Tests 1 and 2 were made with both radiators unpainted and an average of the results gives a difference in the heat transmission in the two radiators of 0.1 of 1 per cent., so

that they are assumed as having practically the same heat transmission value. Lines Nos. 3 and 4 show the effect of painting radiators with two coats of copper bronze for each test. The results of the test show a reduction in the heat transmitted by the radiator of 24 per cent. On top of these four coats of copper bronze two coats of terra cotta enamel were applied. The result of the additional two coats was an increase of 3.8 per cent. above the transmission effect of the bare radiator or 28.6 per cent. above the transmission effect of the radiator with a copper bronze finish. On top of these coats of terra cotta enamel were applied two coats of copper bronze, the same as was applied previously, and the loss in the conducting capacity was shown to be about 26.5 per cent. This is about the same result as was obtained in the first experiments with copper bronze.

In order to determine whether this loss in heat transmission was produced by the pigment of the paint or by the vehicle carrying this pigment, test No. 7 was made using only the vehicle which was a light brown varnish. This test shows a loss of 2.8 per cent. as compared with the unpainted radiator. The same was true when a light oak brown varnish was used. This varnish was applied on top of the coats as previously mentioned. The varnish was followed by two coats of aluminum bronze, and the heat transmission was nearly the same as that shown by the copper bronze, namely a loss of 27 per cent.

The interesting fact is that the transmission of heat was almost the same with 14 coats of paint applied to the radiator as with two coats, and that the effect apparently depended upon the last coat applied and the intermediate coats through which this heat was transmitted had very little effect upon the heat transmission. That is, the heating effect of the radiator was more affected by the condition of the surface than by the material through which the heat was conducted.

Tests 10, 11, 12, 13, 14 and 15 were started with two coats of aluminum bronze. The heat transmission was practically the same as for the aluminum bronze in Test No. 9 in which twelve coats of other paints had been applied, showing, as previously stated, that the various coats underneath the last coat made very little difference in the heat transmission. These coats of aluminum bronze were followed by a series of enamels of different colors as stated in table. You will note, as shown in test No.

XUM

12, that the snow-white enamel gave the best results. The lowest result was given by "no lustre" green. The extreme difference due to color was about 5.4 per cent.

Tests 16 and 17 were made using a different vehicle for carrying the pigment. You will notice in these tests that copper bronze and shellac seem to give better results than copper bronze and linseed oil, so that the vehicle may have some effect in the value of the heat transmission of paints. Tests 18, 19 and 20, made with white lead paints, show that the transmission effect with white lead and oil is practically the same as for unpainted radiators. These white lead paints were followed by coats of zinc paint, as shown in tests 21, 22 and 23. For the light green and white the transmission effect was practically the same as for unpainted radiators. For terra cotta there was a slight reduction in heat transmission.

These tests covered a period of about three months. They seem to show that the poorest coverings are the copper and alu-

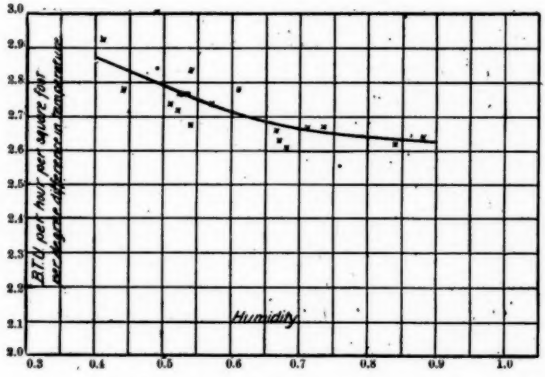


FIG. I.

minum bronzes; the best materials tried were the enamels, while white lead paints and zinc paint are only slightly less in transmission effect than a coat of enamel.

EFFECT OF HUMIDITY.

From columns 9 and 11 the curve shown in Fig. 1 has been plotted. This shows, as has been pointed out before in a pre-

RADIATOR TESTS.

TABLE I.

1	2	3	4	5	6	7	8	9	10	11		REMARKS. Radiator No. 2 Plain in all tests.	
					RADIATOR NO. 1.		RADIATOR NO. 2.						
No. of Test.	Steam Pressure.	Average room temp.	Average temp. of steam entering the radiator.	Difference in temp. between air and steam.	Condensation per hr. per sq. ft. actual surface.	B.T.U.'s rad. per hr. per sq. ft. of surface per deg. diff. of temp.	Condensation per hr. per sq. ft. actual surface.	B.T.U.'s rad. per hr. per sq. ft. of surface per deg. diff. in temp.	Efficiency.	Humidity.			
1	425	74.4	222	148.6	.413	2.82	.413	2.82	.997	.45	1	Rad. No. 1 Plain as received from factory	These paints of two coats each were painted over one another in the order given.
2	"	76.0	220	144.0	.418	2.94	.414	2.925	1.005	.408	2	" " " " " " "	
3	"	63.1	224	156.3	.353	2.16	.438	2.835	.761	.542	3	" " Painted with Copper Bronze	
4	"	72.3	220	148.7	.325	2.08	.432	2.78	.752	.608	4	" " " " " "	
5	"	74.5	220	146.5	.436	2.86	.426	2.78	1.038	.437	5	" " " " Terra Cotta Enamel	
6	"	66.3	218	149.7	.351	2.24	.478	3.05	.735	.482	6	" " " " Copper Bronze	
7	"	74.1	224	150.9	.421	2.67	.442	2.74	.977	.510	7	" " " " Light Brown Varnish	
8	"	72.9	226	154.0	.431	2.67	.442	2.74	.977	.572	8	" " " " Oak Brown Varnish	
9	"	71.8	225	154.0	.318	1.97	.436	2.70	.730	.512	9	" " " " Aluminum Bronze	
10	"	70.5	224	154.4	.324	2.005	.448	2.77	.724	.525	10	" " " " "	This Series follows one another.
11	"	66.7	223	157.3	.442	2.68	.441	2.77	.970	.530	11	" " " " Silver Gray Enamel	
12	"	67.6	224	157.4	.452	2.75	.446	2.72	1.01	.520	12	" " " " Snow-White Enamel	
13	"	64.2	224	160.5	.446	2.66	.448	2.67	.997	.708	13	" " " " Bronze Green Enamel	
14	"	64.0	224	161.0	.429	2.545	.447	2.67	.956	.735	14	" " " " No Lustre Green Enamel	
15	"	70.6	224	154.4	.423	2.62	.423	2.63	.997	.670	15	" " " " Maroon Gloss Japan	
16	"	68.5	224	156.5	.364	2.22	.427	2.61	.850	.680	16	" " " " Shellac and Copper Bronze Powder.	
17	"	67.0	224	158.0	.347	2.02	.469	2.66	.760	.665	17	" " " " Copper Bronze Powder and Linseed Oil.	
18	"	86.9	224	138.1	.379	2.62	.381	2.66	.987	.848	18	" " " " White Paint	Painted over one another.
19	"	83.4	224	140.5	.389	2.65	.386	2.64	1.00	.88	19	" " " " Terra Cotta Paint	
20	"	86.8	224	138.0	.374	2.59	.378	2.62	.989	.84	20	" " " " Light Green Paint	
21	"	77.2	224	147.8	.423	2.72	.418	2.72	1.00	.60	21	" " " " " " Zinc	
22	"	77.7	224	146.3	.408	2.66	.422	2.77	.964	.535	22	" " " " Terra Cotta Paint-Zinc	
23	"	76.0	224	149.0	.418	2.70	.413	2.68	1.01	.540	23	" " " " White Paint Zinc	

vious paper, that the rate of transmission of heat varies with the humidity; that the higher the humidity, the lower the rate of transmission, the probable variation through ordinary ranges of humidity being about 10 per cent. in the coefficient of radiation.

DISCUSSION.

Mr. Macon: In Prof. Allen's paper he shows that the heat emitted from a direct radiator is decreased as the amount of humidity is increased. I asked him if he had any theory for it. He said the best reason he could find was this: that the heat is given off from the radiator in two ways: by radiation and by convection. The radiation will be the same without regard to the amount of vapor in the atmosphere; the convection we might have, if any, would be greater, under the impression that the vapor would help in the conduction of the heat itself. He thinks it is attributed to the fact that when one has vapor in the air its density is less per unit of volume, and therefore the weight of air passing over the heated surface in a given time is less with a greater percentage of humidity.

That seems all very well except when you try to reconcile that with the experience of the human body in cold atmospheres, when the relative humidity is high. We all know that it is a great deal more disagreeable in New York, for example, in winter than it is in Dakota. So far as our bodies tell us, we have got a greater heat emission in cold weather with a high percentage of humidity than we have in the Dakotas, and I cannot quite see how to reconcile the two points.

CCIV.

HEATING AND VENTILATING SYSTEM, FINNEY CHAPEL, OBERLIN COLLEGE, OBERLIN, OHIO.

BY B. S. HARRISON.

(Member of the Society.)

In laying out the systems of heating and ventilation for this building, the following conditions controlled:

Steam was to be taken from the street mains of the American District Steam Co., at a pressure of between ½ lb. and 5 lbs. gauge.

The building to be in use (in part or in whole) for short intervals with long intervals between, of no heat.

It was desired to be able to heat up quickly in part or in whole.

Ventilation was imperative at times and at other times not desired.

The first cost and the annual operative cost were both important items.

For the above reasons the systems adopted and laid out as shown by the accompanying sketches were, a single pipe system of low pressure steam direct radiation, supplemented with a fan blast system and a fan exhaust or vent system. The 7-inch steam supply main from the street is pitched to drain back to the street main until a point is reached under the tower of the building where the main rises to the first floor beams and then pitches to the fan room where it is bled to a trap.

In the apparatus room three branches are taken from the main with valves where they leave the main. One feeds the blast coils and two of them supply the direct radiation of the building. The single pipe mains are pitched with the flow of steam and a condensation return line taken from the end of

each run. All risers to radiators on the first floor and balconies are taken off single pipe and dripped back into the mains.

The branches for ceiling coils in the choir room and ante rooms under the apse are taken off with two pipe connections, the condensation returns being connected into the returns from the ends of the single pipe mains.

All direct radiators in the first floor and balconies are connected up at both ends with a blind nipple between the 4th and 5th loops of a 12 loop radiator, thus dividing it into ⅓ and ⅔. Air valves are placed on the 4th and 5th loops.

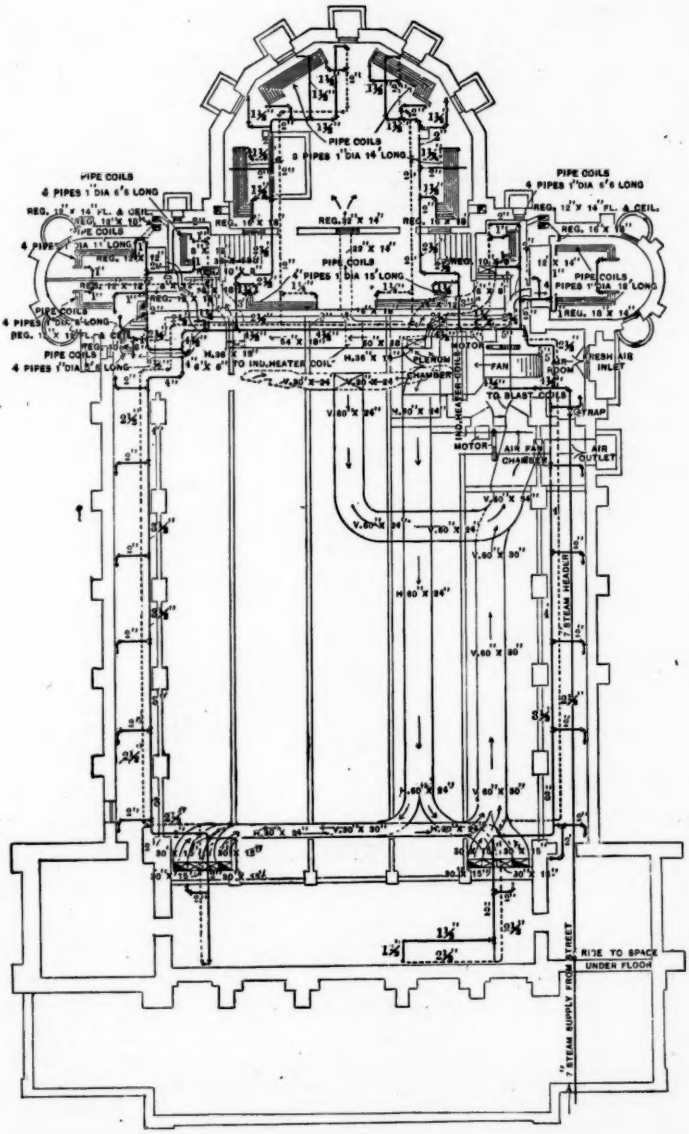
The fan blast system is arranged so that in warming up the building the air may be recirculated by closing the air outlet doors of the vent fan chamber, closing the fresh air inlet doors of the heating fan chamber and opening the door between the two fan chambers.

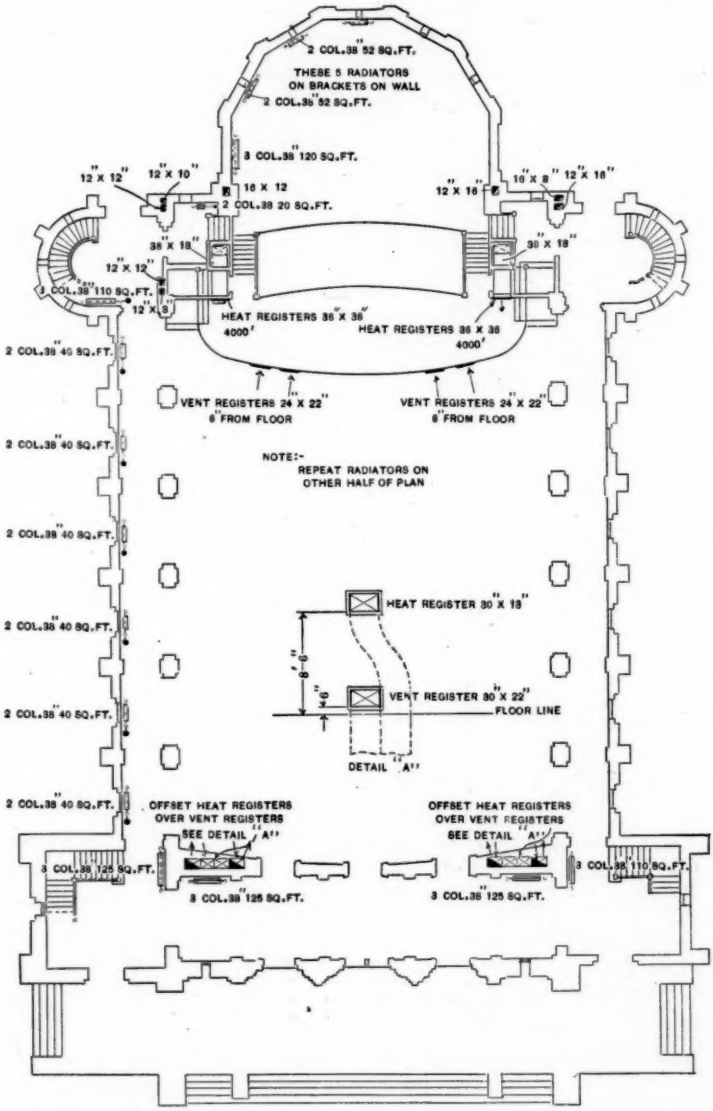
The heating fan is arranged in a blow through rig with mitre type of 1 inch blast coils. The condensation from the steam blast coils, from the direct radiation system and the drip from the steam supply main are all passed through low pressure traps into a hot water coil group under the steam blast coils, as shown on the sections. The heated air from the fan system is introduced into the auditorium at about 8 feet 6 inches from the floor and the foul air is taken out at the floor line.

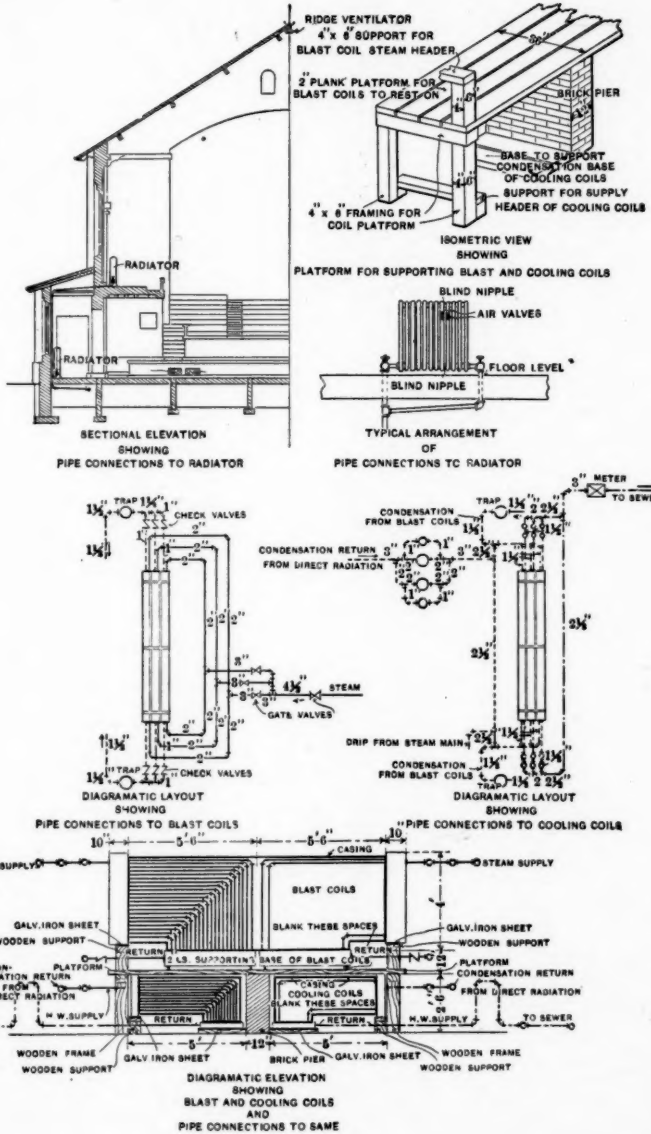
Hand control is used throughout.

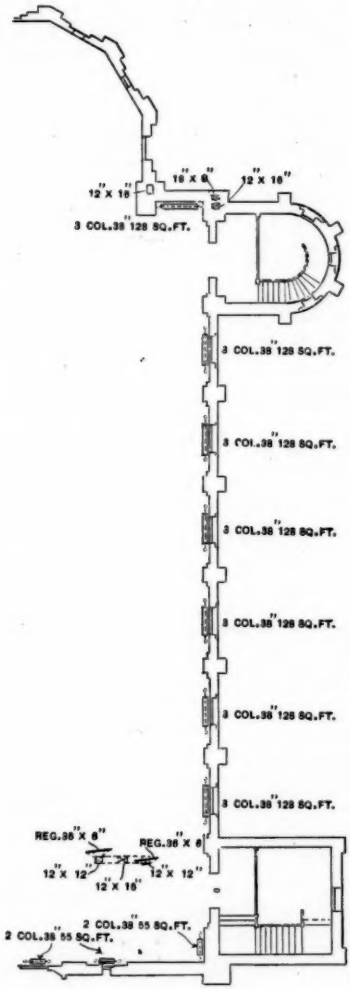
The steam blast coils are 12 rows deep, they are double group 4 feet by 5 feet sections, the total steam coil surface being 2700 lineal feet actual, with a total free area through the double group of 2400 inches. The fan is 6 feet by 3½ feet, three-quarter housed, driven by an A. C. 220 Volt, 60 cycle, 2-phase motor connected to the fan by means of a Morse silent chain. The motor has a speed regulation of about 20 per cent. At full speed the fan delivers 24,000 cubic feet of air per minute. The total free area through the steam and water coils is 22 square feet. The velocity of air through them is 1100 feet per minute. At this velocity, with steam at 220 degrees F., and the incoming air at 0 degree F., the rise of temperature through the steam coils is about 90 degrees F.

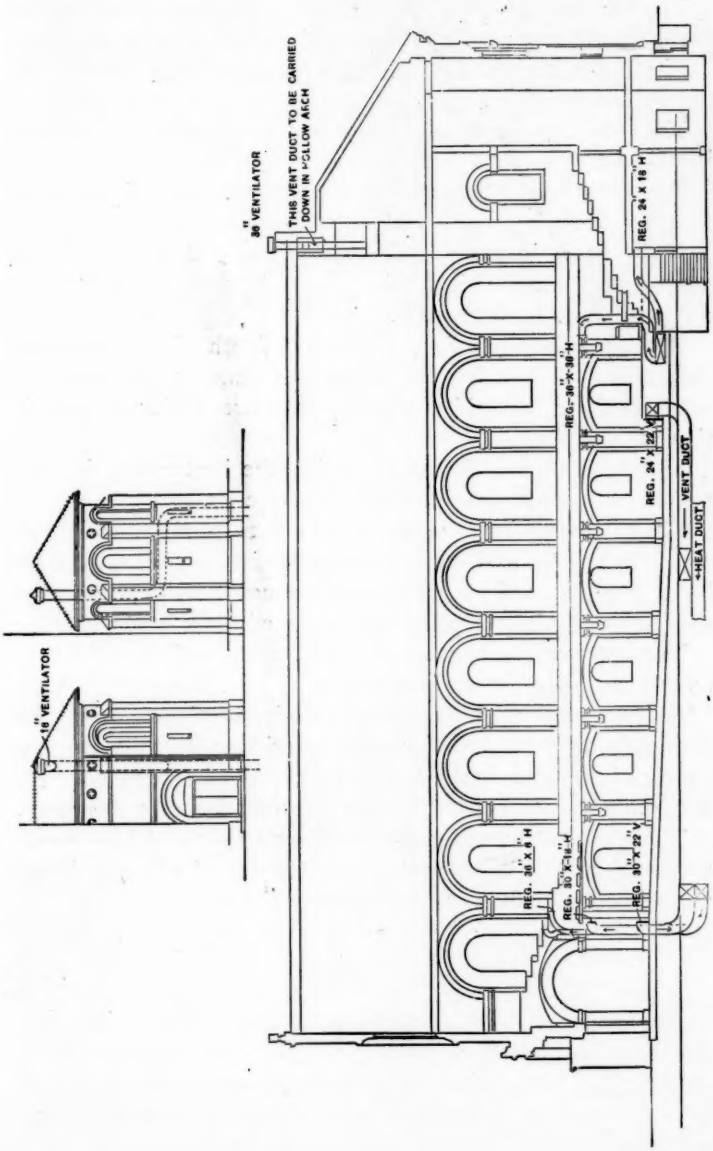
The condensation from the steam coils under these conditions is figured at 2000 lbs.


PIPE COILS
3 PIPES 1" DIA 14' LONG
PIPE COILS
4 PIPES 1" DIA 6'6 LONG
PIPE COILS
4 PIPES 1" DIA 6'6 LONG
PIPE COILS
4 PIPES 1" DIA 11' LONG
PIPE COILS
4 PIPES 1" DIA 15' LONG
PIPE COILS
PIPES 1" DIA 18' LONG
PIPE COILS
4 PIPES 1" DIA 6'6 LONG
PIPE COILS
4 PIPES 1" DIA 6'6 LONG
REG. 22" X 14"
REG. 18" X 14"
REG. 12" X 14" FL. & CEIL.
REG. 10" X 8"
REG. 18" X 14"
REG. 18" X 18"
REG. 10" X 8"
REG. 12" X 14" FL. & CEIL.
REG. 18" X 18"
REG. 18" X 14"
REG. 18" X 18"
REG. 18" X 18"
REG. 18" X 18


2 COL.38" 52 SQ.FT.
THESE 5 RADIATORS ON BRACKETS ON WALL
2 COL.38" 52 SQ.FT.
3 COL.38" 120 SQ.FT.
12" X 12"
12" X 10"
16 X 12
2 COL.38 20 SQ.FT.
12" X 16"
16" X 8"
12" X 16"
38" X 18"
38" X 18"
12" X 12"
3 COL.38" 110 SQ.FT.
12" X 8"
HEAT REGISTERS 36" X 36"
4000'
HEAT REGISTERS 36" X 36"
4000'
2 COL.38" 40 SQ.FT.
VENT REGISTERS 24" X 22"
6" FROM FLOOR
VENT REGISTERS 24" X 22"
6" FROM FLOOR
2 COL.38" 40 SQ.FT.
NOTE:-
REPEAT RADIATORS ON OTHER HALF OF PLAN
2 COL.38" 40 SQ.FT.
HEAT REGISTER 30" X 18"
2 COL.38" 40 SQ.FT.
VENT REGISTER 30" X 22"
FLOOR LINE
2 COL.38" 40 SQ.FT.
DETAIL "A"
2 COL.38" 40 SQ.FT.
OFFSET HEAT REGISTERS OVER VENT REGISTERS
SEE DETAIL "A"
OFFSET HEAT REGISTERS OVER VENT REGISTERS
SEE DETAIL "A"
3 COL.38" 125 SQ.FT.
3 COL.38" 125 SQ.FT.
3 COL.38" 125 SQ.FT.
3 COL.38" 110 SQ.FT.


RIDGE VENTILATOR
4"x 6" SUPPORT FOR
BLAST COIL STEAM HEADER
2" PLANK PLATFORM FOR
BLAST COILS TO REST ON
BRICK PIER
BASE TO SUPPORT
CONDENSATION BASE
OF COOLING COILS
SUPPORT FOR SUPPLY
HEADER OF COOLING COILS
4" x 6" FRAMING FOR
COIL PLATFORM
ISOMETRIC VIEW
SHOWING
PLATFORM FOR SUPPORTING BLAST AND COOLING COILS
RADIATOR
RADIATOR
SECTIONAL ELEVATION
SHOWING
PIPE CONNECTIONS TO RADIATOR
BLIND NIPPLE
AIR VALVES
FLOOR LEVEL
BLIND NIPPLE
TYPICAL ARRANGEMENT
OF
PIPE CONNECTIONS TO RADIATOR
TRAP
CHECK VALVES
STEAM
GATE VALVES
TRAP
CHECK VALVES
DIAGRAMATIC LAYOUT
SHOWING
PIPE CONNECTIONS TO BLAST COILS
METER
TO SEWER
CONDENSATION
FROM BLAST COILS
CONDENSATION RETURN
FROM DIRECT RADIATION
DRIP FROM STEAM MAIN
CONDENSATION
FROM BLAST COILS
DIAGRAMATIC LAYOUT
SHOWING
PIPE CONNECTIONS TO COOLING COILS
CASING
STEAM SUPPLY
STEAM SUPPLY
BLAST COILS
GALV. IRON SHEET
WOODEN SUPPORT
BLANK THESE SPACES
GALV. IRON SHEET
WOODEN SUPPORT
RETURN
RETURN
2 L.S. SUPPORTING BASE OF BLAST COILS
CON-
DENSATION RETURN
FROM
DIRECT RADIATION
PLATFORM
CASING
COOLING COILS
BLANK THESE SPACES
PLATFORM
CONDENSATION RETURN
FROM DIRECT RADIATION
H.W. SUPPLY
RETURN
RETURN
H.W. SUPPLY
TO SEWER
WOODEN FRAME
WOODEN SUPPORT
GALV. IRON SHEET
BRICK PIER
GALV. IRON SHEET
WOODEN FRAME
WOODEN SUPPORT
DIAGRAMATIC ELEVATION
SHOWING
BLAST AND COOLING COILS
AND
PIPE CONNECTIONS TO SAME


12" X 16"
16" X 6"
12" X 16"
3 COL.38" 128 SQ.FT.
3 COL.38" 128 SQ.FT.
3 COL.38" 128 SQ.FT.
3 COL.38" 128 SQ.FT.
3 COL.38" 128 SQ.FT.
3 COL.38" 128 SQ.FT.
3 COL.38" 128 SQ.FT.
REG.38" X 6"
REG.38" X 6"
12" X 12"
12" X 12"
12" X 16"
2 COL.38" 55 SQ.FT.
2 COL.38" 55 SQ.FT.


36" VENTILATOR
THIS VENT DUCT TO BE CARRIED DOWN IN PILLOW ARCH
18" VENTILATOR
REG. 24" X 18" H
REG. 36" X 36" H
REG. 24" X 22" V
VENT DUCT
HEAT DUCT
REG. 36" X 8" H
REG. 36" X 14" H
REG. 36" X 22" V

The total amount of direct radiation is 4095 square feet, and the condensation from the same is estimated at 1024 lbs.

The water coils are 12 square feet gross area or about 5 square feet free area.

The total condensation to be passed through the water coils is 3024 lbs.

The amount of air passed through the water coils at 1100 feet per minute is 330,000 cubic feet per hour.

If the water in the coils is cooled from 200 degrees F. to 100 degrees F., the air passing through will be heated from 0 degree F. to 46 degrees F.

On this basis it was figured that the depth of water coil required was 10 rows, but the coils were made 12 rows deep to preclude the escape of hot water to the sewer under any condition of operation.

The temperature of the air leaving the heater case is controlled by hand regulation of the steam coils.

The discharge from the water coils is trapped to the height of the return base of the steam coils to insure the water coils being kept full, and is then passed through the American District Steam Co.'s meter and connected with the sewer.

The water coils are bled dry when the system is closed down, by means of hand valves in the bases.

In order to provide a means of gravity ventilation when the fans may be shut down, a ridge ventilator extends the full length of the ridge of the building roof, with butterfly dampers in it controlled by means of cords and pulls from the first floor.

The plant has been in operation over a year and has proven very satisfactory of operation and control, the results being very close to the figures used in laying the work out.

DISCUSSION.

Mr. Feldman: In connection with the radiator that Mr. Harrison has shown, dividing it with a blind nipple, so as to use one-third of the radiation in mild weather and two-thirds in colder weather. I know a party in New York that has gotten up a system.

When applied to a large radiator, say fifteen to twenty sections, a drainage pipe (usually ¼-inch) is taken from under-

neath the second section counting from the inlet or supply end, and is carried under the body of the radiator to the return pipe on the far side of the outlet valve. See Figure A.

When applied to a small radiator a drainage chamber, as

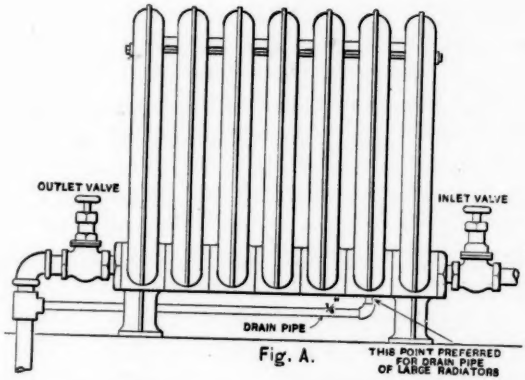


Fig. A.

shown in Figure 2-B, is screwed into the inlet end of the radiator, and from a point between the radiator and the inlet valve a small pipe is taken from this drainage chamber, and is car-

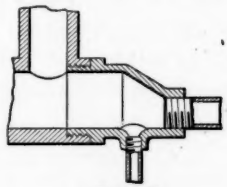


Fig. 2-B.

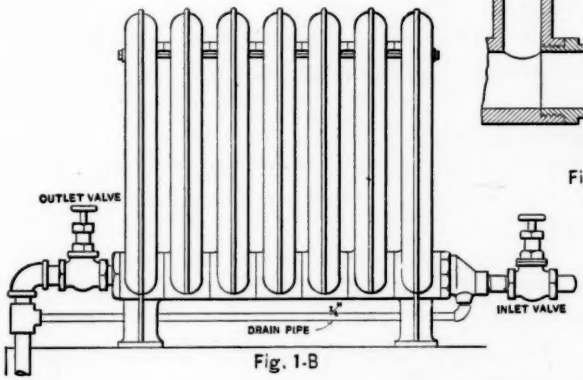


Fig. 1-B

ried to and connected with the return connection, as shown in Figure 1-B.

The drainage chamber fits flush with the bottom of the radiator.

To get full effect of the entire radiator, both inlet and outlet

valves are open and the drainage chamber performs its function, not only in keeping the "hammer" silent, but satisfactorily empties each radiator section of air and mechanically carries this air down with the descending water of condensation. To get partial radiation close the outlet valve and let steam in from the inlet valve; the drainage chamber still prevents the "hammer," but the air is now trapped in all sections except those nearest the drainage chamber.

These sections are kept free from air and remain hot while the sections at the far end are full of air and remain cold. In practice from one-half radiator to two or three sections remain hot, according to the location of the drainage chamber and pipes.

No air-valves are used on a two-pipe system, but are used on a one-pipe job.

President Snow: Any air valves?

Mr. Feldman: He puts an air-cock on a one-pipe job.

Mr. Donnelly: I would ask Mr. Feldman is that a three-way valve?

Mr. Feldman: Either use a three-way valve or a valve above the drainage connection.

Mr. Tait: I would like to ask how he gets rid of the air?

President Snow: He has an air-cock up here which has not been indicated.

Mr. Tait: I understood him to say he could get along without it.

Mr. Feldman: He puts an air-cock only on a one-pipe job; on a two-pipe job I tested it myself and found it working all right without the use of an air-valve; it seems that the two drainage connections answer the purpose.

Mr. Tait: I understood you to say it could be worked without it.

Mr. Feldman: Yes.

Mr. Tait: I would like to ask Mr. Feldman another question. Is that a hot water radiator, a steam radiator or a hot air radiator?

President Snow: A steam radiator, with nipples only at the bottom.

Mr. Feldman: Yes, an ordinary steam radiator.

Secretary Mackay: I think that as the radiator has to be

operated by the ordinary help in a building, the one shown using a steam instead of a hot water radiator, would be best. That would be simpler to operate, because you have a valve on each end of the radiator, similar to a two-pipe radiator; opening one gives a partial radiation and opening two gives the whole radiation. I think it is simpler to use because the hired help would not think of the valve under the radiator. I do not know why Mr. Harrison used the water type of radiator.

Then as to Mr. Feldman's sketch, it would seem that while the radiator has two valves on it, it would be impossible to shut the radiator off from the system without a valve on the small drain pipe, and if used on a gravity apparatus in that way, when shut off, the radiator would fill up with water, lowering the water in the boiler to an extent that might be dangerous if many radiators were closed, and while claiming to give greater control of the radiator it really prevents a proper control of it.

Mr. Feldman: If the air-cock is closed and the return valve at the bottom is also closed, only one part of the radiator is heated up; when the air-cock and return valve are opened the entire radiator is heated up.

Mr. Hale: I will ask Mr. Feldman if he would not get the same result with a one-pipe air-valve. What is the use of having this connection?

Mr. Feldman: With one radiator five sections are heated up right away. About one-third of the radiator was heated up that way and no more.

A Member: What is the pressure?

Mr. Feldman: Just the pressure of the rest of the system, about one or two pounds.

Prof. J. D. Hoffman: It could be done a great deal easier than that by simply putting an automatic valve on the supply end of the radiator and a compression cock on the other end. The automatic valve will take care of two or three laps on the radiator, provided the compression cock is closed; then when they want the rest of the radiator heated up they can open up the compression cock and heat the whole radiator. With the compression valve closed it will heat up three laps of the radiator.

CCV.

SAFEGUARDING OUR PROFESSION.

BY WM. M. MACKAY.

(Member of the Society.)

While we possibly number among our members two-thirds of the competent heating and ventilating engineers in the United States, it is a positive fact that we do not number 20 per cent. of those who attempt to design and superintend the installation of heating and ventilating apparatus, and who, in many cases, lacking knowledge and experience in the subject, design apparatus which, on account of their lack of experience, is faulty both in design and operation and is neither efficient or economical, bringing discredit on the entire profession. This is more noticeable in public work, such as schools and public buildings, where, in many cases, a competent heating and ventilating engineer is not employed, but where the heating contractor is also the designer, and as in this class of work it is customary to accept the lowest bid regardless of the efficiency or completeness of the apparatus for the purpose intended, many of these buildings which should be the best models of heating and ventilation, are the poorest, and are, in many cases, through the lack of knowledge and experience of the designers, dismal failures.

At the last annual meeting of the Society I spoke on this subject under a topic, " The Necessity for Having Ventilation Laws Apply to the Installation of Apparatus in Old as Well as New Buildings," citing a case where a school board composed of fifteen members, in a State which has a school-house ventilating law in force, employed a person who had no knowledge of the existence of the law and no previous experience, to design a ventilating apparatus for a large school building built some years before. After he had completed his design they employed an

architect, licensed by the State, to draw up the contract which was taken by the designer, and the work was installed.

After he had completed the contract I was called in to pass on the work before its final acceptance and payment. Up to this time they were of the opinion that the apparatus, which had been placed during the summer vacation and not operated, was all that they anticipated and desired, and they merely wished it approved before making the final payment. I had to tell them that the apparatus did not come within 75 per cent. of complying with the State law, that it had many faults which were both dangerous to health and life, but that the contractor had done all that he had agreed to under the proposition except that, having designed and installed the apparatus, he did not comply with that part of the proposition where he agreed "to do this work in the best possible manner," and that they, as a school board, and their licensed architect, should at least know and comply with the law.

I also cited another case of a twelve-room school-house in the same State which was formerly heated by hot air with no attempt at ventilation. I advised with the school board as to the best and most economical manner of placing a steam heating and ventilating apparatus which would comply with the State law. The school board found that the law did not apply to buildings already constructed, and so they finally decided to place an ordinary direct-radiation heating apparatus, with no ventilation, in this building occupied by over six hundred scholars, although the saving in cost on the entire apparatus was only about 20 per cent. below what a complete heating and ventilating apparatus would have cost.

I took this matter up with the State Superintendent of Public Instruction, and he wrote, "I regret to advise you that the law does not compel the Board of Education to provide a system of ventilation when a heating plant is installed in a school building erected prior to the enactment of the law," and when I told him that I would use my utmost endeavors to secure legislation which would insure suitable provision for the ventilation of a building when a new heating plant was installed, he wrote, "The information contained in my letter was given with some reluctance as a great majority of boards of education believe that provision for ventilation must be made in all such cases."

Dr. A. B. Poland, Superintendent of Public Schools, New-

ark, N. J., at the National Convention of the Society for the Study and Prevention of Tuberculosis, at Washington, D. C., last May, made the following statement, in the course of his remarks on "Relation of Public Schools to the Anti-Tuberculosis Movement," which was published under the heading:

"FEW SCHOOLS PROPERLY VENTILATED AND HEATED."

"Having attempted to show by the foregoing that the school is an important, necessary and desirable ally in the campaign against tuberculosis, I wish now to mention briefly some of the ways by which the school can make its service most useful and effective.

SCHOOL CONSTRUCTION DEFECTS.

"1. *As to Selection of Sites for School Buildings.*—It is a shameful fact, but none the less true, that in most of our cities until quite recently, little or no attention has been given to the selection of school sites, except upon grounds of convenience of access by pupils or upon grounds of economy. The notion that sunlight as well as abundant air and exercise have any immediate and necessary relation to school efficiency, has been rarely or never considered. One of the immediate effects of this anti-tuberculosis campaign will be to compel communities to open their eyes with reference to the selection of school sites and the location and orientation of school buildings.

"Sunshine, it is said, is one of the surest and deadliest enemies of the tubercle bacillus; certainly the cheapest, when it can be got for nothing. But few of our school architects have ever taken the question of sunlight into consideration in placing a building on a school site. On the contrary, school boards and school architects have stuck tenaciously to the traditional oblong type of school building and placed it so that at least one-half of the building would rarely or never get a ray of direct sunshine. Types of school architecture have been developed, and others should be, which will fit on a site of any shape or dimension and which will admit sunshine into every room for a part at least of each day. The principles of orientation of school buildings have yet to be studied and described.

"2. *As to Construction of School Buildings, Including Lighting, Heating and Ventilating.*—During the last few years there has been great progress in school-house construction. In several States sanitary regulations as to space, heat and light have been established by law. Much more remains, however, to be done. Problems of lighting, heating, ventilating, cleaning, airing, dusting, and disinfecting are still in most instances far from being satisfactorily solved. Take, for instance, one problem, that of artificial ventilation. I have yet to learn of very many school buildings where a perfect, or, indeed, approximately perfect system, considered, of course, from the standpoint of the hygienist and not from that of the engineer responsible for installing it, can be seen in operation.

WRETCHED VENTILATION SYSTEM.

"Scattered throughout the country are school buildings by the thousand wherein artificial heating and ventilating apparatus has been installed that is not only practically useless, but worse than useless, since it compels school children to breathe noxious and often fetid air, when only the window separates them from God's pure atmosphere.

"But it is forbidden to open the windows! Talk of juggernauts, there never was a more hideous juggernaut than that of a worthless system of artificial school ventilation. It is not my purpose to inveigh against artificial heating and ventilating; far from it, but I do protest most emphatically against those pseudo and abortive systems so frequently installed even by some of our most distinguished heating and ventilating engineers.

"I have in mind as an instance a school building of twenty-three rooms, located not far from New York, in the erection of which one of the foremost engineers and publicists was employed to devise and supervise the heating and ventilating system. No care nor expense seems to have been spared; but when the system was put in operation six of the twenty-three rooms could not be heated, and, of course, could not be ventilated. But, despite the protests of superintendent, teachers and pupils, the 'system' had to be worked. It had been paid for, and how could the cost to the city be otherwise justified?

A HIT OR MISS BUSINESS.

"The fact is that heating and ventilating are far from being a science. Sometimes engineers hit it; oftener they do not. It may interest you to know that a friend of mine inspected last summer many of the foremost technical and engineering schools of France, Germany, Holland, and England. Among other famous schools he visited that at Charlottenburg, near Berlin. Here is located, as you know, one of the foremost schools of architects, and engineering, in all Germany, if not in all Europe.

"Discussing heating and ventilating systems, he found that a whole group of rooms in the very building in which the professors gave their engineering instruction had been cut out from the general heating and ventilating system and resort had to gravity methods. On inquiring why this was done, he was told that the artificial methods didn't work. On inquiring further, 'Why do you teach what is impractical?' my friend was told, 'Only because you have to do it.'

"If this can happen in one of the foremost architectural and engineering schools of Europe, what may we expect from inexperienced engineers by whom too many by far of our American school buildings have been experimented with? I am not opposed, however, to appropriate experimenting. We shall have to do a great deal more of it. But I do protest most emphatically against the insistence by so many engineers of school boards, that under no consideration shall windows be raised or lowered, however hot or fetid the air, because it will 'queer' the whole system! If the opening of a single window throws the whole system out of order let engineers devise a cut-off. It should be as easy to cut in and cut out a room in a heating and ventilating system as in an electric lighting system. If not, why not? Let engineers go to work and find out.

"It seems that this convention, devoted as it is to the problem of pure air and open windows, should appoint a committee to get facts and to make recommendations upon the suppression of the artificial heating and ventilating plague, that is widely prevalent and directly opposed to the anti-tuberculosis movement."

There is some truth in his statements. I know of the particular case to which he refers, and I am pleased to say that the

party who designed this heating and ventilating system was not a member of our Society. There are, however, many thousand properly designed heating and ventilating apparatus in this country that do operate properly, showing results, efficiency and economy. I feel that our Society, which is now in its sixteenth year, comprising the majority of the competent and experienced heating and ventilating engineers in the country, should devise some method to protect its members, other competent heating and ventilating engineers, the public, and the children who have to suffer from the mistakes of faulty apparatus designed and placed, particularly in school buildings, making an annual waste of millions of dollars, and bringing discredit on our profession. It is along these lines that I asked our Society at the last annual meeting, if there should be State control for heating and ventilating engineers. The opinion of some of those present was that this matter would right itself in time, they felt that bringing our Society more prominently to the attention of the public would insure competent heating and ventilating engineers being employed for this work, and increase the value of membership in the Society.

I would welcome anything that would improve existing conditions and that would insure the employment of competent heating and ventilating engineers at a fair remuneration for this class of work, and which would prevent the employment of incompetent or inexperienced persons at any price.

It is a fact that many professions and occupations less important than ours are protected by State laws in many, possibly all of the States, preventing any but competent, experienced and licensed persons practicing their profession or calling, and it seems to me that if State protection is not the proper method to safeguard our profession and protect the public from imposition, our Society should formulate some plan to protect its members and to prevent the public from being imposed upon, and to carry out Section 3 of the original objects of the Society, which is, "The maintenance of a high professional standard among heating and ventilating engineers."

XUM

CCVI.

A COMBINATION VENTILATING, HEATING AND COOLING PLANT IN A BANK BUILDING.

BY A. M. FELDMAN.

(Member of the Society.)

The object of this paper is to give data and results of the regular operation of a ventilating, heating and cooling plant installed in the bank building in New York City of the firm of Kuhn, Loeb & Co. In view of the relative scarcity of information of this character and the growing in favor of artificially cooling air supplied for ventilation purposes it is hoped the figures will prove of value. The plant is now in its third year, and some interesting facts have been learned with regard to the best manner of introducing the cool air in summer, to the use of steam heating coils for the refrigerated medium, which, to the best knowledge of the writer, is the first time that it has ever been attempted, and to the amelioration of drafts from windows, and finally to the use of the exhaust air from the banking rooms for cooling the engine-room.

The points to be considered are involved in the part of the plant serving the banking offices of Kuhn, Loeb & Co., comprising about 85,000 cu. ft., in the ground floor of that company's 20-story building on William and Pine Streets. The building is of L shape, giving light in the rear, with the ground floor extending over the entire lot, and a skylight over the extension. Mechanical ventilation, to insure a constant supply of fresh air with a coincident removal of the vitiated air, is provided for the banking offices only. The building has its own isolated power plant, which is located in the basement. Two-thirds of the ground floor is directly over the boiler and engine-rooms, as there is no sub-basement in the building. In the original lay-out the ducts for carrying the fresh air supply to, as well

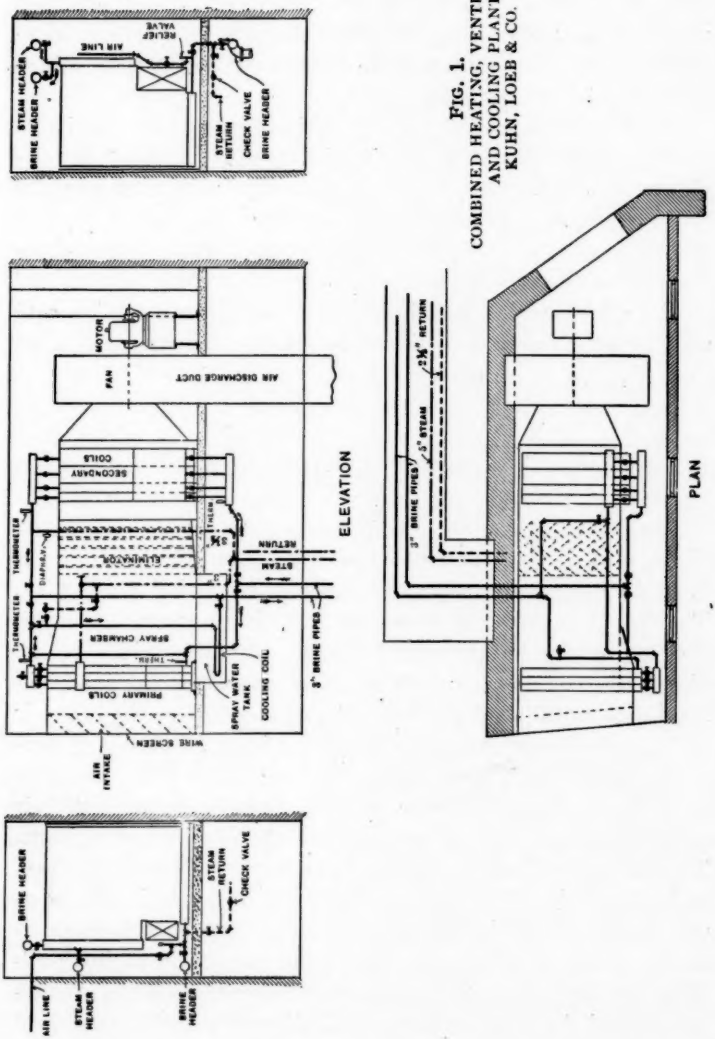


FIG. 1.
COMBINED HEATING, VENTILATING AND COOLING PLANT
KUHN, LOEB & CO.

as the exhaust air from the banking rooms were under the ceiling of the engine and boiler-rooms, with a result that the fresh air was always overheated and odorous from the engine-room, etc., through conditions peculiar to the building. Considerable heat was also transmitted into the offices through the floor, notwithstanding that the latter was insulated underneath with a suspended ceiling of magnesia blocks.

The author was called upon to devise a scheme for the introduction of a supply of fresh air without going through the engine and boiler-rooms in the basement, also for cooling the banking rooms, to counteract the heat from the floor and make the occupants comfortable. After a careful study of the situation, the author designed a *combination ventilating, heating and cooling plant,* which was installed under his supervision, and which has given very satisfactory results for the past three years.

LOCATION OF APPARATUS.

The blower, coils, air washer, etc., were located on a part of the roof over the first floor extension, drawing the fresh air from the court formed by the L shape of the building (Fig. 1). The discharge from the blower was carried downward through the roof, and the ducts were branched under the ceiling of the directors' room, the air also was led in a duct over the false ceiling in the main entrance hall, to allow for delivering the air through the inner wall of the banking rooms (Fig. 2). A suspended translucent glass ceiling was built under the unsightly ducts in the directors' room to hide them. All the fresh air outlets and registers are near the ceiling, that is, top registers. The exhaust registers are in the three other walls near the floor, as indicated in the drawing. Thus the fresh air in winter as well as in summer is being drawn across the room toward the outside walls, where the occupants are usually in sitting positions or relatively at rest, so that draftiness is readily discovered if existing. In other words, there would be danger of drafts if the inlet and outlet registers were both in the outside walls, because of the tendency of the cool air to descend rapidly on the heads, etc.

SPECIAL FEATURES OF THE SYSTEM.

This was found especially to be of great advantage in the summer when the air was being delivered at a temperature of about 8 to 10 degrees lower than that maintained in the room, as the cooler air drops down mostly near the entrance, or public

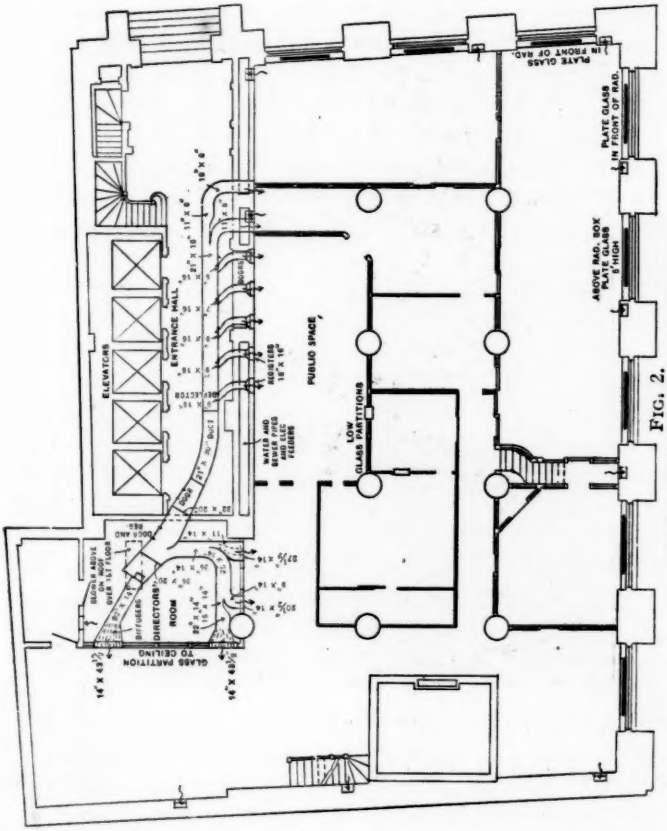


FIG. 2.
VENTILATING SYSTEM, FIRST FLOOR
KUHN, LOEB & CO.

space of the banking office, and not on the heads of the bank officials, as would have been the case were the air introduced through top registers in the outer walls.

The exhaust air from the bank is not much vitiated, on account of the very large quantity allotted per person, and being cool, and

exhausted from near the floor, the author deemed it best to discharge it into the engine-room, with a result that the temperature of the engine-room was reduced more than 10 degrees lower than it used to be before this was done.

To overcome drafts from the windows, plate glass in frames in front of them were installed over the top of the direct-radiator boxes—the glass extending less than half the height of the win-

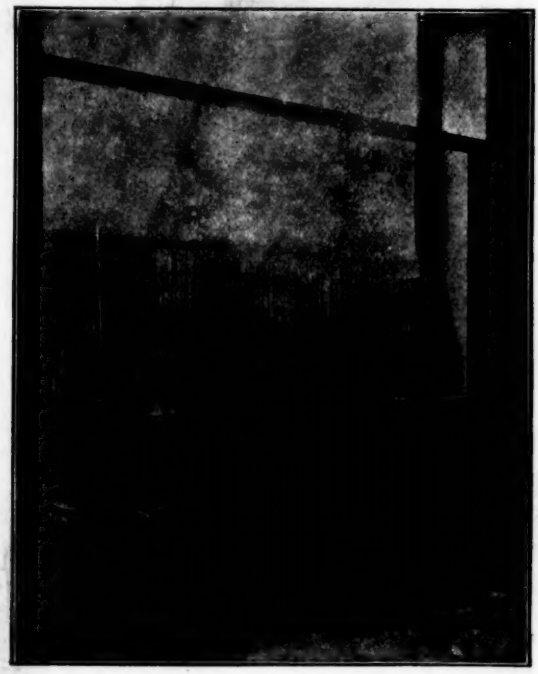


FIG. 3.

dow—the radiators being between the plate glass and window. This stopped the drafts (Fig. 3).

The blower is of the multivane type, 30 inches diameter, delivering 390,000 cu. ft. of air an hour at a speed of 350 r. p. m. or effecting 4.6 changes in an hour.

The air washer cleans the air by an arrangement of fine water sprays, reducing the temperature of the air when the water is cool, and by means of eliminator plates the suspended particles

of water are removed from the air before it is drawn over the heating coils into the blower. In some of the neighboring low buildings cannel coal is being used on old-fashioned grates. Large particles of soot are discharged out of the low chimneys and they used to be drawn in the banking rooms with the fresh air supply of the blower. Also since the United States Assay Building is not far away bad odors would occasionally be brought in from it whenever the direction of wind was favorable. The air washer entirely eliminated these objectionable features.

SAME COILS USED FOR HEATING AND COOLING.

As there was no room for the installation of cooling coils in addition to the tempering and heating coils, two sets of headers were provided with shut-off valves, so that the tempering and heating coils are used in the winter for heating the air and as cooling coils in the summer by circulating refrigerated calcium chloride through them. Of course there are separate steam and brine mains leading to the coils. The coils are of the standard hot blast mitre type of 1-inch wrought iron pipe, galvanized to prevent rusting from the deposit of moisture on the outside when cold brine circulates through them. There are six rows of pipe, aggregating 275 sq. ft. in the primary coils, and twelve rows in the secondary coils aggregating 443 sq. ft. surface, or a total of 718 sq. ft. The steam pipes and headers are insulated with magnesia sectional covering and the brine pipes and headers with standard cork insulation.

The steam and brine are carried from the engine-room a distance of about 80 ft.

The steam headers are provided with automatic temperature regulation which enables them to maintain a uniform temperature in the bank (Fig. 4).

As the apparatus is removed from the immediate supervision of the engineers, three recording thermometers were installed: one to register the outdoor temperature at the intake of the fresh air, one the temperature of the air after it has passed the fan, and the third thermometer to record the bank temperature. The clockwork and dials are located in the engine-room in sight of the engineers (Figs. 4 and 5).

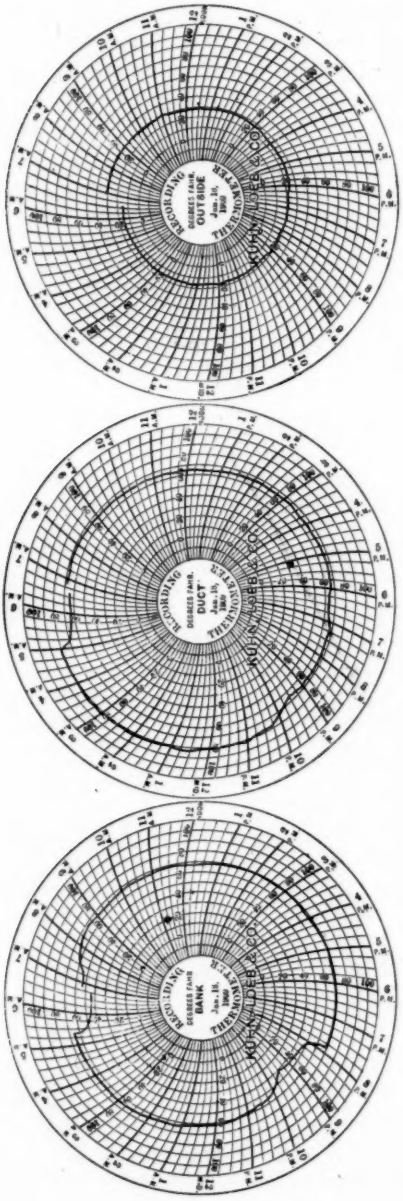

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FIG. 4.

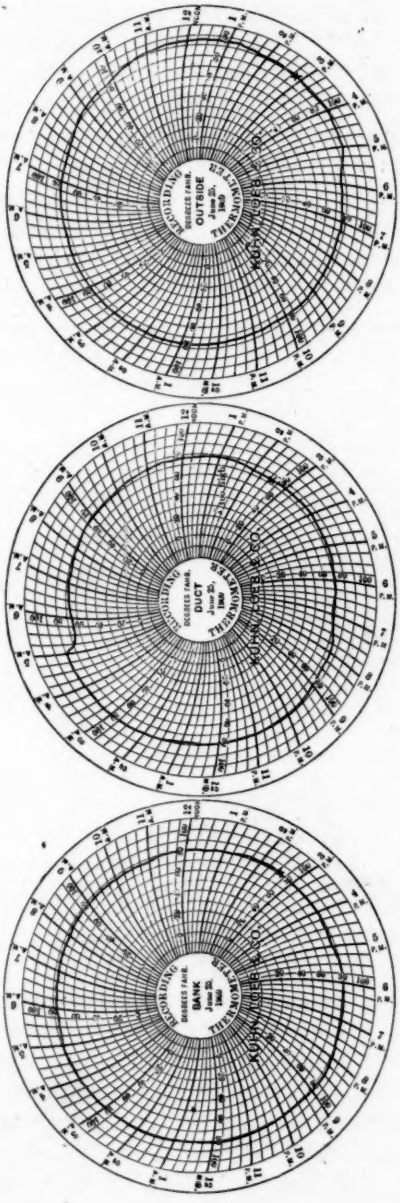
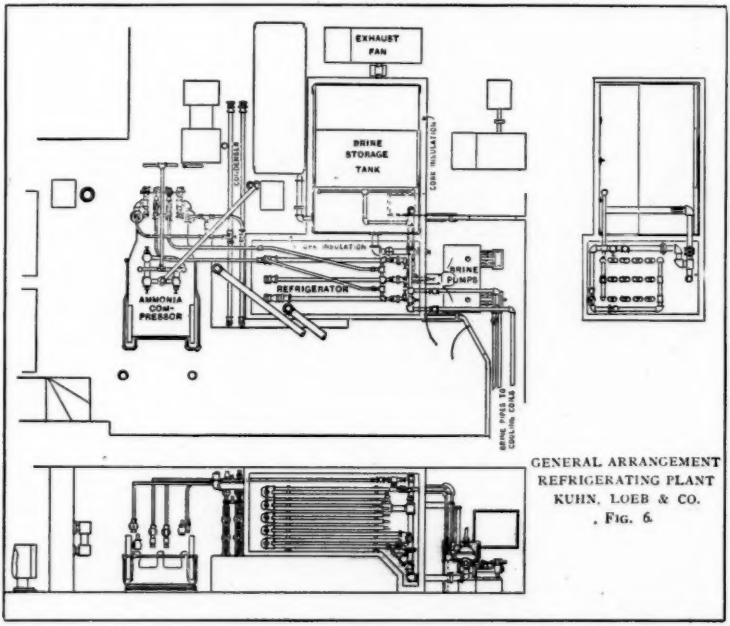


FIG. 5

THE REFRIGERATING PLANT.

The refrigerating plant for cooling the calcium chloride brine, which is being circulated through the coils to cool the air in the summer, consists of a 20-ton marine type machine of the compression system with cross compound steam cylinders and two ammonia cylinders, double-pipe condenser and double-pipe refrigerator. Everything is so piped that one-half of the plant could be run in case the other half is disabled (Fig. 6).



GENERAL ARRANGEMENT
REFRIGERATING PLANT
KUHN, LOEB & CO.
FIG. 6.

The author calculated that 30 tons refrigeration were necessary, but there was no room for a larger machine, so a brine storage tank was installed with the idea that the machine is to be run for a few hours at night time to store up low-temperature brine, which helps the machine during the daytime.

There are two 6-inch by 8½-inch by 6-inch duplex steam-driven pumps for circulating the brine through the cooling coils. The pumps deliver the brine from the storage tank through the

refrigerators and up to the coils. The brine from the latter returns to the brine storage tank. A meter is installed on the delivery main near the pumps. There are also thermometers.

The piping, coils and headers are so arranged that were there greater capacity in the refrigerating machine, the air would be cooled to a lower degree, so as to remove a great deal of the absolute humidity. For instance, the primary coils could be utilized for cooling purposes and indeed a part of the main heater, the other part to be used to reheat the air to the desired temperature, controlling it automatically. Under such conditions a considerably lower relative humidity could be obtained in the banking rooms.

The plant has turned out to be of just the necessary capacity to lower the temperature of the outside air about 20 degrees F., and maintain the air in the bank 10 degrees lower than outside in the hottest weather (Fig. 5). This difference was found to give the desired comfort, without causing unpleasant drafts, or chilled sensation in entering the room.

From 14 to 16 rows of coils are used in the early morning to bring down the temperature in the bank, which has become warmed during the night, and only 12 or 14 rows to do the work during the entire day, in the hottest weather, to maintain the 10 degrees difference between outdoors and the banking rooms.

TEST NO. 1, JUNE 25, 1909.

Taking for an example an observation and test made in the afternoon of June 25, 1909, the following data were obtained:

Cooling coils used—12 rows, 2 in the primary and 10 in the secondary coils, or a total surface of 447.6 sq. ft.

Outdoor temperature, 91 degrees F.

Outdoor relative humidity, 53 per cent.

Temperature—the air was cooled down to and introduced into the banking rooms at 71 degrees F.

Average temperature in the banking rooms, 81 degrees F.

Relative humidity in the banking rooms, 63 per cent.

Temperature of brine at circulating pump, going out 35 degrees F., returning at 38 degrees F., a rise of 3 degrees F.

Temperatures of brine at cooling coils entering and leaving same 35¼ degrees F. and 37¾ degrees F. respectively, a rise of 2.5 degrees F.

Amount of calcium chloride brine circulated through the system was equivalent to 21.5 cu. ft. per minute.

REFRIGERATION ACCOMPLISHED.

Taking the weight of a cubic foot of calcium chloride liquid at the density which was being used as 73 lbs., also assuming the specific heat as 0.82 the heat (H) absorbed by the brine from the cooling coils, and therefore from the air in an hour would be equal to $(21.5 \times 73 \times 2.5 \times 0.82 \times 60) = 193{,}048$ B. T. U.

One ton refrigerating capacity is defined as being equal to the heat transfer involved in the freezing or melting of 2,000 lbs. of ice in 24 hours. The latent heat of ice being 142.2 B. T. U. per pound for 2,000 lbs., this represents 284,400 B. T. U. per 24 hours, or about 12,000 B. T. U. per hour.

In other words, 1 ton refrigerating capacity for one day is equivalent to the performance of 12,000 B. T. U. every hour. If we divide the total heat (H) as calculated by 12,000, the result will be the tons of refrigeration accomplished by the brine on the coils, thence on the air, namely,

$$(193{,}048 \div 12{,}000) = 16.1 \text{ tons refrigeration.}$$

As shown above, there was 0.5 degree F. loss in the two main calcium chloride brine pipes between the pump and the bunker of coils, which represents by the same method of calculation an equivalent of $(21.5 \times 73 \times 0.5 \times 0.82 \times 60) \div 12{,}000 = 3.21$ tons refrigeration. Total work done by the refrigerating machine is equal to 19.31 tons, not counting losses between the refrigerator, storage tank and pumps.

Thus the machine has been tasked to its full capacity and somewhat over.

AIR COOLING.

The volume of air which passed over the cooling coils and was introduced into the rooms was measured by an anemometer and

amounted to about 390,000 cu. ft. per hour. The air was cooled from 91 degrees to 71 degrees, or 20 degrees F. One cubic foot at the average temperature along the coils gives off in being cooled 1 degree, 0.0175 B. T. U., hence 390,000 cu. ft. cooled 20 degrees F. gave up 136,500 B. T. U. in an hour, an equivalent of a performance of 11.3 tons of refrigeration for cooling the air (12,000 B. T. U. representing the heat equivalent of one ton refrigeration).

ABSOLUTE HUMIDITY.

The weight of aqueous vapor in a cubic foot of air at different temperatures and percentages of saturation is called the absolute humidity.

The absolute humidity of the outdoor air, at 91 degrees F. and 53 per cent. relative humidity is 8.074 grains; that of the air in the banking rooms at 81 degrees F. and 63 per cent. relative humidity is 7.103 grains. The 390,000 cu. ft. of air at 91 degrees F. will be about 382,000 cu. ft. at 81 degrees F. Therefore the moisture contained in the air in the bank is less than that originally contained in the same air by an amount equal to (390,000 × 8.074 — 382,000 × 7.103) = 435,500 grains, or 62.2 lbs. Moisture has been added to the air in the rooms by the amount of vapor given off by the occupants of the rooms in the products of respiration.

This quantity, however, is small in comparison with the total amount, as the average supply of moisture by the human body is 1-15 lb. per hour. There are only about 33 people constantly in the banking rooms, but the number of those coming in and leaving was not ascertained. Assuming all together about 40 persons in the banking rooms, it would make a correction of about 2.7 lbs. 8.074 × 390,000 ÷ 7,000 = 449.8—total pounds of aqueous vapor contained in the air per hour before being cooled. 7.103 × 382,000 ÷ 7,000 = 387.6—total pounds of aqueous vapor in the air in bank per hour. 2.7 = aqueous vapor given off by occupants of bank per hour. Therefore, 387.6—2.7 = 384.9, total pounds of aqueous vapor brought into bank per hour. 449.8 —384.9 = 64.9, representing the pounds of moisture removed per hour from the air and which has been deposited on the cooling coils due to the process of refrigeration.

The latent heat of vapor at the average temperature of 81 degrees F. is 1057.6 B. T. U. This multiplied by 64.9 and divided by 12,000 equals the equivalent of 5.7 tons of refrigeration. This represents the tonnage of performance in condensing the above amount of vapor and reducing the absolute humidity of the air delivered to the banking rooms.

Thus the total tonnage of refrigeration in the process of cooling the air and reducing the absolute humidity amounted to (11.3 + 5.7) 17.00 as against calculated 16.1 tons of refrigeration performed by the calcium chloride in the coils. Practically, the former figure ought to have been slightly less to account for losses in transmission. But the discrepancy may be accounted for in the readings of the thermometers which are of commercial type and not finely graduated. With the data observed the author also checked the tonnage with the aid of chart No. 2 given in W. W. Macon's paper on "Air Cooling by Refrigeration," presented at the annual meeting of the Society, 1909, and found about the same, namely, that an equivalent of 5.3 tons of refrigeration were used in condensing and removing the above amount of vapor from the outdoor air. With the aid of the chart he also found that the air was not fully saturated when cooled to 71 degrees F. No observations were made on the conditions of the relative humidity of the air as it left the bunker of coils.

The relative humidity in general was measured by means of a sling or whirled psychrometer. This instrument consists of a pair of thermometers, provided with a handle, which permits the thermometers to be whirled rapidly, the bulbs being thereby strongly affected by the temperature of and moisture in the air. The bulb of the lower of the two thermometers is covered with thin muslin, which is wet at the time an observation is made. The psychrometric tables published by the United States Weather Bureau were used in these calculations for obtaining the relative and absolute humidities.

TEST NO. 2, JUNE 26, 1909, 10 A.M.

Cooling coils in use—4 rows of pipe in the primary and 10 rows in the secondary, or a total of 526.2 sq. ft. of cooling surface.

Outdoor temperature, 84½ degrees F.

Outdoor relative humidity, 68 per cent.

Temperature the air was cooled down to, 66 degrees F.

Average temperature in the banking rooms, 77½ degrees F.

Relative humidity in the banking rooms, 74½ per cent.

Temperatures of calcium chloride at circulating pump going out and returning respectively—37½, 40½—a rise of 3 degrees F.

Temperatures of brine at cooling coils—37¾, 40¼—a rise of 2.5 degrees F. in refrigerating the coils, due to cooling the air reducing the absolute humidity.

The pump was running at the same speed, circulating 21.5 cu. ft. of calcium chloride per minute.

REFRIGERATION ACCOMPLISHED.

As the amount of calcium chloride circulated and rise in temperatures of the calcium chloride were the same as on the previous day, the same amount of work was performed by the refrigerating medium on the coils and air, namely, an equivalent of 16.1 tons of refrigeration.

AIR COOLING.

The air was cooled from 84½ degrees to 66 degrees F., a drop of 18.5 degrees F. The quantity of air passed over the coils was about 390,000 cu. ft. per hour. One cubic foot of air at the average temperature along the coils cooled 1 degree gives off .0177 B. T. U., hence the 390,000 cu. ft. cooled 18.5 degrees F. gave off $(.0177 \times 18.5 \times 390{,}000) = 127{,}686$ B. T. U. in an hour, or an equivalent of work done of 10.64 tons of refrigeration in cooling the air.

ABSOLUTE HUMIDITY.

The absolute humidity of the outdoor air at 84½ degrees F. and 68 per cent. relative humidity is 8.531 grains per cu. ft., that of the air in the banking rooms at 77½ degrees F. and 74½ degrees relative humidity is 7.488 grains per cu. ft. Correcting the volume of 390,000 cu. ft. of the air due to the change

in density would make about 384,000 cu. ft. at 77½ degrees F., hence (390,000 × 8.531 − 384,000 × 7.488) = 451,700 grains, or 64.5 lbs. of water. Correcting for the vapor given off by the occupants in the process of respiration, 67.2 lbs. of water were condensed on the coils and removed from the air per hour, due to the refrigerating effect of the calcium chloride in cooling the coils. The latent heat of vapor at the average (84½ degrees to 66 degrees) temperature of 75¼ degrees F. is 1061.6 B. T. U. This multiplied by 67.2 lbs. and divided by 12,000 gives an equivalent of 5.9 tons of refrigeration. This represents the tonnage of performance in condensing the above amount of vapor and reducing the absolute humidity of the air delivered to the banking rooms.

From the chart above referred to it figures out about 5.75 tons of refrigeration. The total tonnage of refrigeration in this test in both the process of cooling the air and reducing the absolute humidity amounted to (10.64 + 5.9) = 16.54 tons, as against the 16.1 tons of refrigeration calculated from the performance of the calcium chloride in the coils.

COEFFICIENT OF HEAT TRANSMISSION AT 780 FT. PER MINUTE VELOCITY.

The coils, as stated, were of the standard hot blast mitre type of 1-inch pipe. The full area of the secondary coils is equal to 8⅓ sq. ft. As the quantity of air delivered over them was about 390,000 cu. ft. per hour, or 6,500 cu. ft. a minute, the air velocity was 780 ft. per minute.

From the test of June 25, 1909, the figures are:

The mean temperature of the air, 91 — 71 = 81 degrees.

The mean temperature of the brine in coils = 36.5 degrees.

Difference of temperature between the air and brine = 44.5 degrees F.

Total heat absorbed by the coils per hour = 193,048 B. T. U.

Total cooling surface in coils 447.6 sq. ft.

Heat transmitted per degree of difference of temperature per square foot per hour $= \frac{193{,}048}{447.6 \times 44.5} = 9.7$ B. T. U.

From the test of June 26, 1909, the figures are:

The average temperature of the air was 75.25 degrees F.

The average temperature of the brine in coils, 39 degrees.

Difference of temperature between the air and brine, 36.25 degrees.

Total heat absorbed by the coils per hour, 193,048 B. T. U.

Total cooling surface in the coils, 526.2 sq. ft.

Heat transmitted per degree difference of temperature per square foot per hour $= \frac{193{,}048}{526.2 \times 36.28} = 10.6$ B. T. U.

The average for the two tests is 10.15 B. T. U. per square foot of galvanized iron pipe with an air velocity of about 780 ft. per minute at the given difference of temperatures, and given temperature of refrigerating medium. With lower temperatures of the latter and different velocities of the air passing over the coils, the coefficient of heat transmission will vary.

It is to be hoped that the Committee on Tests of the Society will take a hold of this problem, and by using test thermometers and calibrated instruments will obtain further data to establish standards. It is especially hoped that the method suggested in this paper of refrigerating the air down to low temperatures and then reheating it will be followed and observations made with various low relative humidities.

It is the belief of the writer that more comfort and better results would be obtained by furnishing drier air of a uniform relative humidity of about 50 per cent. to 60 per cent. with rather a small difference of temperature between the outdoor and indoor conditions.

DISCUSSION.

Mr. Davis: Mr. Feldman says on the fourth page of his paper, "The coils are of the standard hot blast mitre type of 1-inch wrought iron pipe, galvanized to prevent rusting from the deposit of moisture when cold brine circulates through them."

Mr. Feldman: It should be the air on the outside.

Mr. Davis: I would like to ask you if the results obtained show that the galvanizing did prevent rust, what results you got?

Mr. Feldman: Henceforth, if I design a plant I would use cast-iron. Three or four years ago there were no cast-iron sections suitable for blower work. Whether the galvanizing of the pipe has worn off I cannot tell. The outside surface is eating away on the first coil already. I cannot see further back. So far the coil is still standing.

Mr. Davis: The reason I asked that question was that in a recently designed apparatus of very much the same type we used cast-iron instead of wrought to circulate the brine through.

Mr. Donnelly: I would like to ask whether the air washer is used in the summer time.

Mr. Feldman: We do not use it in the summer. We found that the moisture deposited on the chilled coils was sufficient to remove the dust. On the other hand, if the washer was used it added too much humidity in the summer.

Mr. Donnelly: What is the space between the coils of your washer?

Mr. Feldman: About seven-eighths of an inch. With this space and the pipes of the coils in zigzag the moisture on them abstracts the dust, therefore we found it is not necessary to use the air washer in the summer. I placed a coil in the collecting tank of the air washer through which a part of the brine circulates. My object was this: since I anticipated I did not have enough refrigerating capacity in my machine, I wanted to assist the cooling with the cool water of the air washer; but, as I stated before, this increased the humidity, therefore we did not use it.

Mr. Donnelly: I would ask Mr. Feldman if he attempted to catch the condensation from the coils in the summer time to see what quantity it was?

Mr. Feldman: No, I did not attempt to do that.

Mr. Donnelly: It would be possible to do it?

Mr. Feldman: Yes.

Mr. Donnelly: I think it would be interesting to catch that.

Mr. Feldman: The figure I got was about sixty-four pounds per hour, estimated with the help of humidity tables.

Mr. Macon: Speaking of the desirability of measuring the amount of actual condensation of the vapor, I should think it would be much more important to learn the actual precipitation for this very reason. Mr. Feldman has found by the use of

the hygrometer that he did not get saturated air. Now it is hard to explain, or at least I cannot see how it is possible that he has gradually reduced the air in temperature; and as he has reduced the temperature he has not only condensed the vapor to the saturation point, but seems to have gone beyond and has got less vapor present than you would naturally expect with a saturated condition. In other words, he seems to have accomplished an impossible thing, and that being the case, we certainly ought to feel that the only proof that it is possible to do so is to obtain by actual measurement the amount of vapor that is condensed.

Mr. Feldman spoke of the desirability of cooling the air to a low temperature and then reheating it somewhat. In that way, by cooling it to a very low temperature, he plans to extract a good deal of the vapor, and then by reheating it, in order that the inflow temperature into the room may not be too low, he plans to keep the relative humidity quite low.

It is doubtful if the application of this idea is as broad as it would seem at first consideration. Mr. Feldman has in mind the delivery of air for cooling purposes through the same system used for ventilation purposes during the heating season. There is a maximum limit beyond which it is not desirable to go with respect to the velocity of the inflowing air, in order to avoid draftiness. On the other hand, the volume of air delivery in the warm weather must be great enough and the temperature of the air must be low enough so that this volume of air on warming from the incoming temperature to the temperature of the room can absorb the amount of heat transmitted from out of doors into the interior of the room and the amount of heat given off by the occupants.

It was shown in the speaker's paper in the volume of the proceedings for 1909 that, generally speaking, the lower the temperature to which the outdoor air is cooled in the refrigerating apparatus, the less the refrigerating capacity required, owing to the greatly diminished amount of air necessary for the work. A limit is, of course, the minimum temperature at which it is safe to cool air on account of the amount of condensation of the watery vapor which must be taken care of. In short the plant might be designed to cool outdoor air to say 50 degrees F. and then with no reheating except what must of course take

place in transit from the refrigerating apparatus to the room to be cooled, the amount of air necessary can be calculated. If one plans to reheat this air a few degrees after it leaves the refrigerating apparatus it is apparent that a greater volume of air will be necessary, and therefore the refrigerating plant will have to be larger. If we assume in this case that 50 degrees is the lowest practical limit to which air may be cooled, it will be seen that a plant with the reheating idea requires a larger refrigerating outfit, demands the consumption of heat for reheating purposes, and does not deliver the air with any less watery vapor per cubic foot than the plant without reheating. In the plant with reheating the larger volume of air may entail some difficulties arising from register velocities; with the plant without reheating arrangements as outlined, difficulties with drafts are minimized.

A brief analytical statement of the case may be of interest.

Let S=the space to be cooled in cubic feet.

N=the number of persons in the room.

R=the square feet of direct radiation or equivalent for heating purposes.

Then 250 R is equivalent to the heat loss in B. T. U. in zero weather, or approximately the total amount of heat transmission through the exposed walls of the building. If the refrigerating plant is designed to maintain the indoor air at a temperature of about 10 degrees less than that outdoors, it is feasible for a rough estimate, to place the heat transfer in the warm weather from outdoors to indoors as 10/70ths of the heat transfer in zero weather. This should perhaps be increased 20 per cent. to take into account the effect of the sun's rays and to cover other contingencies, so that the heat transfer through the exposed walls may be stated as equal to $12/70 \times 250$ R.

To this should be added the heat emitted by the illumination and the heat given off by each of the persons present in the room. For this calculation we may eliminate the heat from the lighting system, while the animal heat may be taken at 400 N, each person giving off 400 B. T. U. per hour. Therefore

Heat transfer $= 12/70 \times 250\,R + 400\,N$ ..... (1)

Suppose that the space per person in the room cooled is 500 cu. ft. and that the equivalent direct radiation is in the ratio of 1 to 50 to the cubic contents, then $S \div N = 500$ and $S \div R = 50$

and S/R=50. Then R=S÷50=10 N. Substituting the value of R in equation 1 we find that

Heat transfer=12/70×2500 N +400 N=828 N .....(2)

The volume of air necessary per hour in cubic feet, Q, must be such that heated from inflowing temperature to room temperature it will absorb the heat supply from out of doors and by the human beings. Suppose that it is 85 degrees out of doors; that it is desired to keep the interior at 75 degrees; that the air is admitted into the room at 65 degrees. Then the air may be heated through 10 degrees. Then

$$Q\times 10/55=828N \text{ and } Q=4550N.$$

It is thus seen that the air delivery will have to be over 4500 cu. ft. per person per hour, while the ventilation plant may have been designed for no more than 1800 cu. ft. per hour per capita. Obviously this volume of air would cause trouble.

If the air were introduced at a point 20 degrees below desired room temperature, the volume would be half of this, or 2275 cu. ft., and if the air were introduced at 50 degrees, so that it could be warmed through a range of 25 degrees, the amount of air necessary would be 1820 cu. ft. per capita.

It is possible that one may count on a register velocity 20 per cent. greater with the cooling system than with the heating system. In that case if the ventilation plant was designed for 1800 cu. ft. per minute, one might feel justified in allowing for a delivery in the summer time of 2250 cu. ft. per person, in which case, by the foregoing calculations, one could introduce the air at 55 degrees and therefore provide for a plant that would cool perhaps to 50 degrees. If it were practicable to cool air to, say, 45 degrees, the vapor contained would be reduced and reheating could be employed so that the incoming air would be 55 degrees. Certainly if the incoming air is higher the volume of air would seem to be prohibitive.

This calculation can be extended for different ratios of space per person and space per square foot of equivalent direct radiation. For example if the ratio of S to N is 500, and the ratio S to R is assumed at 100 the heat transfer figures out at 614 N and one finds that the air may be introduced at 60 degrees and the volume per capita need not be over 2250 cu. ft. The air could then be cooled in the refrigerating plant at 50 degrees and slightly reheated before delivery into the room. If, however, the

air were cooled to 50 degrees and not reheated at all it could be introduced into the room at 55 degrees. Only three-fourths as much air would then be needed as when introducing at 60 degrees, and therefore the refrigerating plant would need to be but three-fourths the capacity of the plant in which reheating is attempted for the example worked out.

Mr. Feldman: My idea would be, in the same plant, if I had a 30-ton refrigerating plant I would cool the air to about 50 degrees before it reaches the fan, then I would have one steam coil to heat it to the temperature I needed. For instance, I have shown that during the day when it was 91 degrees outdoors, we cooled the air to 71 and kept the bank at 81. I did not want to keep it any cooler than 81. My idea would be to cool the air to, say, 50 degrees, and then reheat it to 71 with the thermostatic control. By cooling it to 50 degrees I would take out more of the absolute humidity and thus reduce the relative humidity.

The figures of one test are as follows:

	Dry Bulb.	Wet Bulb.	Relative Humidity.	Wt. in Grains Per Cu. Ft. of Aqueous Vapor.
Outdoor	82	75	72	8.474
Bank	75	71	82	7.672
Duct at Blower...	67½	65	87½	6.400

The interesting point is this: The occupants of the offices did not know they were getting a higher relative humidity in the office. One of them once remarked: "The temperature was 75, but it felt as if it were 65, because the air was so dry." Now the absolute humidity was lower, but the relative humidity was higher. While we always consider in the winter that comfort is due to the proper relative humidity, it looks to me that the proper amount of absolute humidity is what gives us comfort. A cubic foot of air outdoors on the day of the test contained eight grains of moisture and a cubic foot of air in the rooms contained only 7.6 grains, which means the absolute humidity in the bank was lower than the absolute humidity outside, notwithstanding that the relative humidity was ten per cent. higher, and still it was absolutely comfortable.

Another interesting point I wish to bring out is this: I never found the air passing over the coils fully saturated.

President Snow: I would like to ask Mr. Feldman if he knows of any plants that are arranged as he suggested, to cool the air down to a point a number of degrees below that in the room and then reheating it, or if he or any one present knows how the cooling of the Senate and House at Washington is accomplished.

Mr. Feldman: There are two plants in New York City; that is the Stock Exchange and the Kuhn, Loeb & Co. building. In the Stock Exchange they have separate coils for cooling and heating. There they have about a 350-ton refrigerating plant, but they do not heat the air there. I could not do it in my case because I had not enough refrigerating capacity. It is not a question of cost in places of this kind, because they want comfort.

President Snow: I thought possibly some one present was familiar with what is actually in use in Washington. I know that some recommendation was made in a voluminous report by Prof. Woodbridge some years ago to the committee of the Senate and the committee of the House.

Mr. Macon: Mr. President, I think the last line of figures must show us that Mr. Feldman's bunker of coils has really cooled the air below 67½ degrees. By the time he measured it it was 67½ degrees and had an absolute humidity of 6.4 grains, but somewhere within that bunker it was cooled to the saturation point, so that you really are not able to measure your minimum temperatures.

Mr. Feldman: I will say there is a space between the last bunker of coils and the main duct where the reading of temperatures was taken. It is therefore possible that a decrease in the saturation took place due to expansion of the air. I found every time that there was about 10 per cent. higher relative humidity in the rooms than compared with outdoors. But the comfort of the people evidently is measured by the absolute and not by the relative conditions.

President Snow: Will you kindly state or restate the maximum drop of temperature that you consider advisable to attempt to attain between inside and outside? If it is 90 outside how low should an engineer attempt to decrease that temperature in order to avoid that sensation of chill to one entering from the outside?

Mr. Feldman: I am only telling of the result attained in my

case. I found on an average that the outdoor air had to be cooled twenty degrees to maintain in the rooms eight to ten degrees lower than outdoors. I do not believe in taking this as a general rule. The conditions in the case in question are peculiar. We have not only the doors and windows to contend with, but also heat transmission through floor, as the engine and boiler rooms are directly below.

President Snow: Then, as the members understand it, it would not be advisable to drop that low temperature, if it is 90 outside, to below 80 in the room?

Mr. Feldman: No, sir; never do it. I know on that particular day, the 25th of June, it was 81 degrees in the bank; and it was absolutely comfortable, judging from the opinions expressed by the members of the firm. With 82 degrees outdoors I keep the temperature in the rooms at 75 degrees. I would not attempt to make it 72 or 70.

Mr. Macon: I have visited this plant, but I did not go into the banking offices until banking hours were closed and even then the air seemed decidedly balmy and pleasant. As Mr. Feldman says, the proof of the temperature difference between outdoors and indoors depends on the satisfaction of the people who have to live in the atmosphere. They are perfectly satisfied and think they have a dry atmosphere. While they have not a higher absolute humidity as compared with outdoors, the relative humidity is higher.

Mr. Davis: The point we do not want to forget is that if we attempt to use a brine with a very low temperature, that is, below freezing point, in order to lower the temperature of our air, then we begin to accumulate frost on the coils, and the accumulation of that frost would, of course, cut off your air. You cannot get your air through.

Mr. Feldman: The warm air going over the coils very seldom allows frost to accumulate. You need not have the brine colder than 30 degrees. You can cool the air to any temperature you want by having the number of coils increased. In my case I use a maximum of fourteen rows of pipes to produce my effects.

Mr. Davis: What is the temperature of the brine?

Mr. Feldman: In my case, 35.

Mr. Davis: And you expect to get your air, what?

Mr. Feldman: I get down the air to 71 from 91. If I wanted to cool it down further, instead of using the fourteen coils at the same temperature, I could use more coils. Using more coils would cool the air to a lower temperature with the same brine temperature.

Mr. Macon: Is there not a minimum limit between the temperature of the brine and the final temperature of the air? In other words, you cannot get your air down to 40 degrees unless you have got an infinitely large coil.

Mr. Feldman: I do not expect to get it down to 40.

Mr. Davis: It may be a satisfaction for the gentleman to know that in a recent installation now in progress in Chicago, in one of the modern hotels, they are using almost identically the figures given by Mr. Feldman. They are using brine at 35. They are introducing their air into the room they expect to cool 10 to 20 degrees lower than the temperature of the room, and I might further add that that is about the effect that is produced at the celebrated Pompeian Room in the Annex Hotel at Chicago.

Mr. Feldman: I would suggest that you should have some of your Chicago people to see whether they can get some more data on that Pompeian Room and tell us for the benefit of the proceedings.

Mr. Davis: We hope to have some data on that hotel installation. They have very kindly offered every facility for getting them.

CCVII.

EXAMPLES OF WIND EFFECTS ON VENTILATION AND HEATING.

BY H. W. WHITTEN.

(Member of the Society.)

The effects of wind blowing against a building are manifold. The most apparent effect is the inleakage of air through crevices, particularly those about the movable windows and doors. In cold weather this inleakage becomes sensible or evident in the form of cold draughts which are often noticeable at a distance from the walls toward the interior.

The volume of this inleakage varies in proportion to the velocity of the wind, sizes of crevices, and means of egress of air from the building. It is also affected in a small degree by the pressure exerted by the expanded warmed air inside of the building. This pressure must be overcome before the outside air can enter. During the heating season this inleaking air, being of a lower temperature than that at which the air inside is desired to be, must be heated.

Both these phenomena are apparent and their effects are common knowledge. Recent investigations have shown, however, that the variation in the volume of inleakage due to variation of wind velocity is much greater than was generally believed.

The least apparent effect, and in the writer's opinion the most important, is the outflow of warmed air through crevices in the sheltered sides of buildings.

Windows and doors are constructed with the primary object of excluding draughts from outside, but are not so well adapted to prevent air currents escaping from the inside.

The wind strikes an obstruction, a building, is diverted from its natural course and is forced to pass by and over the

obstruction. In doing this its speed is accelerated, the parted currents uniting at some distance beyond the building resuming their normal velocity.

This action produces an area of low pressure in the lee of the building which acts as a partial vacuum. This partial vacuum acts as a continuous pump on the crevices in the lee sides. As the pressure of the inside warm air is naturally outward, the combination of this pressure with the partial vacuum outside produces a greater loss than is sustained on account of inleakage, i. e., assuming aggregate amount of crevice on each side to be equal. This loss is greatly increased when other means than wall crevices are employed to admit outer air, such as cold air inlets for hot air furnaces, supply inlets for indirect or fan systems, etc.

It has been well said by a writer on this subject that "we are prone to notice only that which is evident to the senses." This outward flow of air is not attended by disagreeable draughts and, unless special means are taken to detect it, is not evident to the senses.

A few typical tests made by the writer and others the past winter in this connection should be of interest.

Given a school building, rectangular in shape, ends of building facing North and South, having stairway windows only in these ends; East and West sides divided into school rooms, each having 5 windows 5 feet wide by 9 feet high, window sills on a level with tops of pupils' heads when seated. Windows having usual clearance. Rooms heated by a fan system designed to supply 1800 cubic feet of air per hour per pupil, with inlet velocity of 750 feet per minute. Wind north-west, velocity 14.5 to 15 miles per hour, outside temperature 33 degrees. Room No. 5 situated on the East side of first floor of building, one room removed from South end, showed an average rate of supply velocity of 817 feet per minute and a vent velocity of 340 feet per minute. Inlet and outlet of same size. Inlet 8 feet above floor, outlet at floor and both on opposite side of room from windows. This showed a loss of 457 feet per minute. An air test of this room showed 10 parts of carbon dioxide in 10,000. This loss was practically all above the breathing line and frequent complaints of headaches among scholars occurred.

Other rooms on the East side of building showed as follows:

	Rate of supply.	Rate of vent.
1st floor, Room No. 3	760	410
1st floor, Room No. 6	753	396
2d floor, Room No. 13	690	315
West Side:		
1st floor, Room No. 7 (partly sheltered)	660	700
2d floor, Room No. 14 (exposed to strongest wind effect)	410	705

TEMPERATURE CONTROL IN USE IN THE BUILDING.

Average temperature East rooms at the breathing level.....73°; at floor 70°.
" " West rooms, breathing level.....68°; " " 58°.

A test of another school building with wind at 18 miles per hour and outside temperature 30 degrees, building heated and ventilated by gravity indirect system, showed an average of 20 per cent. loss from the supply ducts in rooms on the windward side and an addition of 60 per cent. to the vent velocity.

Rooms on the leeward side of the building showed an addition of 30 per cent. to the supply velocity and a reduction of 62 per cent. of the vent velocity.

A school building having a few corridor windows on the North side, and school room windows on the East, South and West was tested with typical results, as follows: Wind, 20 miles per hour, direction North-West. Room No. 26 on East side of building, two movable windows, 7 feet wide by 9 feet high, one tight window 10 feet wide by 9 feet high, sills level with breathing level. Inlet 8 feet from floor, 4 feet from East wall, volume of air supply 2340 cubic feet per minute, volume of air passing out vent 1451 cubic feet per minute.

Room No. 28 South side of building, near East end, windows same as No. 26, volume of supply 1863 cubic feet per minute, volume of air passing vent 1311 cubic feet per minute.

A test made by Mr. A. B. Franklin of Boston and the Massachusetts District Police on a school building some years ago is also interesting. Wind, 25 to 30 miles per hour, and blowing toward a majority of windows in the building.

Room No.	Air supply at inlet.	Air removed at outlet.
11 (exposed	1536 cu. ft. per min.	2367 cu. ft. per min.
12 "	1533 " " " "	2307 " " " "
13 "	1996 " " " "	2838 " " " "
14 "	2244 " " " "	2990 " " " "
15 (partly sheltered)	2200 " " " "	2368 " " " "
16 " "	760 " " " "	805 " " " "
20 (exposed)	1694 " " " "	2391 " " " "
21 (partly exposed)	2517 " " " "	2777 " " " "
22 " "	1609 " " " "	2031 " " " "
23 " "	2253 " " " "	2762 " " " "
24 " "	1389 " " " "	1653 " " " "

Room No.	Air supply at inlet.	Air removed at outlet.
25 (partly sheltered)	2301 cu. ft. per min.	2288 cu. ft. per min.
30 " exposed	1984 " " " "	2394 " " " "
31 (exposed)	568 " " " "	1154 " " " "
32 (partly sheltered)	1602 " " " "	1773 " " " "
Hall (sheltered)	7833 " " " "	5786 " " " "
35 (partly sheltered)	2153 " " " "	2442 " " " "
34 "	1863 " " " "	2148 " " " "
36 (exposed)	933 " " " "	1404 " " " "

A High School building was recently tested by Prof. H. C. Anderson of Michigan University, there being some question as to whether the heating contractor had put in a competent apparatus (fan system). The supply seemed of sufficient quantity and temperature, but rooms on the exposed sides of the building could not be satisfactorily heated. After shutting down the fan the supply ducts were closed in the rooms on the exposed side of the building and, with all doors and windows closed, it was found that as much air was being removed from the vent ducts as the fan system was supposed to supply. During this test the outside wind was of moderate velocity.

The writer recently had occasion to examine the ventilating system of a hospital. The heating season was over and the fan was not in operation. Supply inlets were in inner walls and about 10 feet from floor. Vents were about 12 inches from floor. Outside wind 6 to 7 miles per hour. Anemometer showed no movement of air at inlets. Window crevices showed some inleakage on exposed sides and outleakage on sheltered sides. Vents in rooms on exposed sides showed a normal outflow, but those in rooms on sheltered sides showed a reverse current into the rooms. An examination of the attic (which was quite large) showed that the vent ducts ended at the attic floor and were covered with ¼ inch mesh wire screens. There were a few windows in the attic and a ventilator about 4 feet in diameter was placed on the roof. Very little air movement could be detected through the ventilator which was of the ordinary hood type. The vents from rooms on the exposed side showed an upward current into the attic, but those on the leeward side showed a corresponding downward flow. Average velocity in each case was about the same. Odors of drugs could be detected in rooms far remote from where such drugs were used. The wire screens covering attic vents leading to rooms on sheltered side of building were covered with a cobwebby sort of dust, while those covering vents from the opposite side of building were clean.

Tests of several buildings in which the leakage about outer openings had been standardized by means of a metal expansion joint showed an average difference between supply and vent flow of 10 to 15 per cent., the greater part of this being due to difference in temperature of air at these points.

DISCUSSION.

President Snow: Is there any discussion of Mr. Whitten's paper? It will be well to take up Topic No. 13 in connection with this paper, as it has a bearing on it: "The effect on the ventilation of office buildings heated by direct radiators where weather strips are used on the windows." That can be taken up and is not intended to interfere in any way with the free discussion of Mr. Whitten's paper as read.

Mr. Donnelly: Mr. President, I think this paper points out very clearly the value of weather-stripping, the value of protection to windows and crevices, in localities where before very little attention has been paid to them. I think it has been too much the practice to put weather-stripping to protect the windows only on the windward side. This shows the perhaps even greater value of protecting windows on the leeward side. It also shows the value, I think, to some extent, of cross partitions in buildings. And I have noticed in many office buildings lately that they are putting many doors in the corridors, so they may cut the building up, not only for fire protection, but it also cuts it up for the air to come in on the windward side and out on the leeward side. I remember some time ago in an office in New York we were able to raise the temperature of the room five degrees by closing the transom over the door. We were on the windward side and the air could very readily get in and out of the room; but by closing the transom and preventing the air from going out of the room we, to a great extent, prevented the air from coming in. This shows to a great extent the advantage of weather-stripping to prevent leakages on the windward side.

Mr. Chew: Mr. President, I have talked with Mr. Whitten about this topic, taking the opposite side of the question to bring out information. A few years ago a paper was presented

in the Society by Henry C. Meyer, Jr., to the effect that the ventilation of office buildings in New York City was interfered with on account of the floor space being held to be too valuable for renting purposes to be wasted in flues for heating and ventilating. Now we hear Mr. Whitten's paper, which proposes in some measure to reduce the possibility of air getting in or getting out, when it is often needed, particularly in direct radiator heated office buildings. It looks as if this paper was all for heating and very little for ventilation, that is, it is for stopping ventilation.

I believe that in the smaller rooms and suites of offices, where most people are put to work, and not where the president or some other company official has plenty of room to do nothing, more ventilation than they get now through the air leakage is positively needed. The point for consideration is whether protection to public health and the necessity of ventilation come first, or whether it is the pocket-books of the men who are getting together in New York City to repeal the factory ventilation law and who have only a mercenary interest. They do not care about the people who suffer from impure air. That is the point. I believe in some sorts of buildings that there would be absolutely no objection to stopping ventilation by leakage. I believe in other cases that the very thing advocated here might work a hardship.

Prof. Carpenter: I think that it is nearly always true that the subject or question of heating is in a way opposed to that of ventilation. If we have cheap heating we almost always do it at the expense of ventilation. If we have a great amount of ventilation we must have heating to pay for it. Those two things face each other as basic propositions in nearly every case. Now it seems to me that it does not follow that we would have poor ventilation because we have our windows tightened up. It might, however, follow that what Mr. Chew suggests is true, but not necessarily so. As a rule, we desire to have controlled ventilation, ventilation that we can perfectly control. If two-thirds of our ventilation escapes through windows and through cracks and crevices in the walls, as was apparently the case in one of the buildings mentioned in the paper just read, it is apparent that we should not have full control of this ventilation; and consequently it is reasonable to me, from my stand-

point, at least, to believe that we can get better ventilation with the windows tightened and a full control of it. On the other hand, take the case which Mr. Chew refers to, where there is no ventilation, but the normal conditions supplied, it probably would be a hardship to the users of the rooms, the occupants, to close up and make the windows tight. That is, it seems to me in the case of direct radiation we had better not have the weather strips or have the windows tight; but in the case of controlled ventilation, where we are introducing enough air for ventilation purposes, it would be better to have the windows tight and have the rooms so built that the ventilation would come where we expect it to and do the work that we want it to.

Mr. Whitten: In regard to the matter brought up by Mr. Chew, I think Prof. Carpenter has stated the question very clearly, and it is possible that by standardizing the leakages from crevices in buildings to a minimum amount, sufficient air change might not take place in a portion of the building. Where a special ventilation is provided it is, I think, unquestioned that the outer openings should be made as tight as possible in order to prevent waste, and not deplete the ventilation at the breathing line.

In regard to office buildings, I have recently investigated three buildings in the city of Detroit, one of which Prof. Allen is familiar with. I found this from the reports of a number of the attendants and engineers in charge and the owners: that where the leakage from the windows was controlled, in a comparatively short time the occupants had been educated to opening their windows and getting as much or as little ventilation as they needed, but when the wind was adverse and the temperature low, they were very glad to be able to protect themselves and not leave it to such a wide margin of guess as would prevail without some method of practically controlling the situation.

Prof. Kinealy: I think that engineering consists in conserving the forces of nature for the benefit of mankind; and in our heating and ventilating work we wish to supply a quantity of warm air for the use of the occupants of the buildings. To let a lot of cold air blow in wherever it may happen to be able to enter is not ventilating a building. It is far better to distribute the heating service of a building and make the building so that the best results can be obtained from the heating service, so that

the people occupying the building will be properly and thoroughly warmed, and then let in the air. Let us arrange our building and let us arrange our heating system so that we will accomplish the results that we have planned to accomplish. And to do this it is absolutely necessary, I think, to prevent the flow of air into the building from the outside in places where we do not want it to flow in, and to prevent the warm air from flowing out from places where we wish to keep it.

Now that must be done by building walls that will be impervious to the passage of air and then protecting the windows and door openings so that cold air will not flow in. What we want to do is to regulate the supply of air and the supply of heat. To put a heating apparatus in a building and then allow the cold air to flow in so as to carry away the heat neither ventilates the building nor does it do any good. On the contrary, it does harm. It prevents the building from being properly warmed and it exposes the occupants to bad influences of cold, disagreeable drafts.

TOPICAL DISCUSSIONS.

TOPIC NO. 3.

"The Minimum Fee for Professional Services."

Secretary Mackay: I wanted to say a few words on that, Mr. President. In the articles of incorporation of our Society section 8 says: " To establish a uniform scale of prices for all professional services." So that it is within our province to touch upon that subject. Occasionally I get questions from our own members and from those who are not members asking what is the proper charge for Heating and Ventilating Engineers for designing and superintending the installation of work. I have referred them at times to different members of the Board of Governors and to special committees; I had one from the United States Government two or three weeks ago asking that particular question in connection with our own members. I referred it to Mr. B. S. Harrison, vice-president of the Society, and after talking the matter over with him I stated in reply that it varied from five per cent. for plans and supervision to sometimes five and five, depending upon the intricacy and the distance. The American Institute of Architects, as you possibly all know, have an established minimum price, which was, up until January of this year, five per cent. for plans and supervision for the work, with an additional charge for engineering work when necessary, paid by the owner of the building in addition to the architect's charge. At the last January meeting of the American Institute of Architects they advanced their charges, on account of the increased cost of labor and other things, to six per cent. as the minimum charge, and I think that it would be the proper time and place to take up the question of what Heating and Ventilating Engineers should charge for plans and specifications and supervision of work.

TOPIC NO. 4.

"The Fire Risk in Connection with Heating and Ventilating Systems."

Secretary Mackay: Some years ago Mr. Donnelly suggested to the Society at an annual meeting that it was right and proper that we, as a Society, should become members of the National Fire Protection Association; that the Mechanical Engineers' Society and others were members of it at that time. The Board of Governors immediately took action, sending it to two of the Chicago members, as the Secretary of that association was in Chicago, and asked them to investigate and report back to the Board of Governors as to whether it would be desirable or wise to become members of the association. Both of these gentlemen, engaged differently in the profession, reported adversely to the matter and no action was taken. At the following annual meeting Mr. Donnelly brought the matter up again, the report of these gentlemen was read and Mr. Donnelly made a motion that the Society become a member of the Fire Protection Association. The board made application and were accepted and we received some of their papers, which were largely the adoption and approval of certain electrical appliances and things of that sort—very little was done in connection with heating and ventilation. By order of the Board of Governors we wrote the Society that some representative of the Society should be placed on a certain committee and also that another committee should be formed, the title of which should be "Necessity for Fire Protection in Connection with the Placing and Operating of Heating and Ventilating Apparatus," of which a representative of our body should be a member. I got a reply back dated August 20, 1908, stating that they would consider the matter of forming such a committee.

This was reported to the Board of Governors of our Society at its next meeting, and I was instructed to ask whether, their office being in Chicago, it should be a western member, resident in Chicago, or whether it should be an eastern member, located near the Society in New York. I received no reply to my letter. Then it was brought up at a meeting of the Board of Governors, and the question was raised whether we should further continue in the organization, seeing that we had not been able to materially benefit them and had not received any benefit

ourselves, the American Society of Mechanical Engineers having dropped out of it—one reason we were urged to join was because they were in. It was the consensus of opinion and the vote of the entire membership of the Board of Governors that we should resign membership in it and the Secretary be instructed to notify the association to that effect. I have their reply regretting our action. Since then Mr. Donnelly has written me that he regrets that we have resigned, that it places him in a peculiar position, as he is allowed to be a member of the association by virtue of the Society being a member. It was not done on the ground of economy, it was just the feeling that the Society was not benefiting them or being benefited by them; and one of the members of the Board of Governors said that if the Fire Protection Association wanted anything in connection with heating and ventilation they would come to the American Society of Heating and Ventilating Engineers and they would get it just as freely as though we were members.

Mr. Hale: In connection with Mr. Donnelly's remarks, it would seem to me that this Society ought to approve the paper which he proposes to read on the subject of fire protection. Mr. Donnelly states that he has looked into the subject and question of regulations, and it would be very interesting to have a paper of that sort.

Secretary Mackay: I would mention that the paper that Mr. Donnelly sent in was very largely extracts from the printed report of the New York Board of Fire Underwriters. It was sent to the Committee on Publication and they decided that as it was largely a quotation from a printed article, that, while it could be considered as a topic, it could not come up as a paper. That was the decision of the Publication Committee and I so notified Mr. Donnelly at the time.

President Snow: Well, that being the case, it would be read under the discussion of the topic. It can be read, Mr. Donnelly, if you desire, under that provision.

Mr. Chew: Topic No. 5 is really different from what Mr. Donnelly has it, and it comes at the request of some people who think that decidedly better heating apparatus would be installed for the unsophisticated buyer if there were some legal requirements. The suggestion which brings up this topic was that a man could not do anything in a building that he wanted to do.

Various authorities provide plumbing regulation and provide a plumbing inspector to see that the provisions are carried out. In view of the fact that there is so much heating work done which causes reflection upon and trouble to men engaged in legitimate heating work, there might be a decided advantage to have some action by the Society to look into the installation of heating apparatus in the cheaper forms of buildings with a view of compelling the use of sizes of different parts which would insure proper service, less waste of fuel, and less danger from fire.

Whether or not the other members think that this Society should ever undertake to formulate any plan or induce any city to adopt an ordinance of any character that would insure better installation of heating plants is a matter for the members to consider.

TOPIC NO. 5.

"Legal Regulations for the Installation of Heating Systems for Residences."

Mr. Donnelly: I think about two years ago we discussed the advisability of Heating and Ventilating Engineers joining the American Fire Protection Association. I joined myself personally as an associate member because the heating and ventilating engineers had joined. Now I understand the Board of Governors are going to withdraw. That leaves me as a sort of captain without a ship. I have been looking over the Fire Protection reports and I find that in various lines of industry all the way from 15 per cent. to 25 per cent. of fires are credited to the heating apparatus, power plant, or something in which we are probably interested. The Collinwood school was a good illustration of it. They said the heating apparatus set the school on fire. I believe we should be interested in this subject and protect ourselves against any wrong impression that the public may have that the heating apparatus sets buildings on fire.

There had been no special committee of the National Fire Protection Association on this subject of fire risk in connection with the heating and ventilation of buildings, but the boards of underwriters in several sections of the country have formulated their rules and have compulsory legislation. I wish that the

Heating and Ventilating Engineers were members of the Board of Fire Underwriters, because they get all the legislation they want. If you ask them in New York what are the fire underwriters' rules they say it is in the law. Twenty years ago it was not any of it in the law, but they kept at compulsory legislation until all they want is in the law, and they say to the insured, "We are helpless; it is in the law." They were the framers of it and got it through. One of the laws is that you must not put a piece of steam pipe or hot water pipe closer than two inches to wood unless you cover it with tin, and then you can go within one inch; and another is that no beam can be notched more than two inches deep. Now if you cannot notch more than two inches and you cannot put pipes closer than two inches to the wood without putting tin over it, it is very evident you cannot put pipes under the floors. So every steam contractor in New York City who notches a beam and tins it, if he notches the beam more than two inches, breaks the law. There are laws governing the covering of pipes. There are many laws in sections of the building code covering chimneys, covering hot air flues, and they have all been passed by the influence of the Board of Fire Underwriters.

However, in all these matters the National Fire Protection Association is largely remodeling its affairs. They are having special committees on all these matters. Now although the Heating and Ventilating Engineers were members for several years of this association, no delegate was ever sent to its meetings.

As I understand, what the association has done about drying inflammable materials, it used to be the practice to dry these materials on an endless belt inside of a drying room, moving slowly, and this belt would go outside the drying room, and there an exhaust fan would take up the material and deliver it through another pipe to adjoining buildings. They had some bad fires and now they have got a regulation that the belt going out of the drying room must travel at least fifteen feet, I think the regulation is, before they allow them to pick this drying material up and convey it to another building, and that over this fifteen feet of belt and around it they must have good fire protective apparatus. They learned that by experience in one instance where a fire occurred in the drying room and was con-

ducted outside on this endless belt and whisked by the fan to another building, causing a $150,000 fire.

I think there are a good many things in connection with a drying apparatus that the Heating and Ventilating Engineers' Society should keep in touch with and send some representatives there. I attended their meeting in May in New York and met many men whom I knew in other lines there, and I find two or three members of our Association are members of it—Adams Brothers, of Baltimore; Furness Brothers and Gillette, of Philadelphia. I think our members should be members of this association. It tends to keep fire losses down and tends to get building codes.

I have handed in extracts of the building code. I think they should go in our transactions; not for the benefit of the New York members—they can always get it—but for our information as to the method of handling chimneys, partitions and wooden floors, the method of building flues and protecting hot steam pipes. Where there are no regulations still, those members would like to follow good, common sense regulations and probably know what they were compelled to do. Then again if they were published in our transactions I think it would be well to have the building codes of Boston and Chicago and other large cities, which differ very much from the New York code.

TOPIC NO. 7.

"The Average Temperature of the Air from Registers in Furnace Heating Systems with Inside Air Supply."

TOPIC NO. 8.

"The Proportional Reduction in Velocity of Air Flow and Loss of Temperature in a Rectangular Flue of 4 x 12 Inches, Compared with an 8-inch Round Flue, Both Working on Gravity with an Initial Temperature of 140 Degrees."

President Snow: I believe in this section of the country, or a little further west, it is more customary to use the inside supply instead of the outside. Topic No. 7 was put by an easterner to get the ideas of the westerners. The topic is open for discussion.

Mr. Macon: I would like to ask any member if he can tell us this: that where it is common to design systems with outside

air supply, say with 130 or 140 degrees as the air temperature in the air piping, what would you expect the temperature to be in that air pipe if you had only an inside supply? Would it be 150 or 160 or 110 or what?

Mr. G. D. Hoffman: The question of temperature of the air at the register would depend altogether on the temperature of the air outside. If it was very cold outside you would have to have the air at the register hotter or you would not heat the room. I have tested the air coming out of registers in my own house a number of times, and I found it wholly depended upon the temperature of the outside. But on a cold day, where it was down to zero, 125 degrees temperature of the air coming out of the register was sufficient to warm the room.

There is another question, and that is, it depends upon the volume of air and the diameter of the pipe. If we had a room that was ten by twelve and we had a ten-inch pipe going into the room we could heat it with a temperature of air at 125. If we only had an eight-inch pipe going into the same room we would have to increase the velocity of the air in order to heat that room, and the only way we could increase the velocity would be to raise the temperature.

Prof. Kinealy: I think it is very difficult to say what is the average temperature, but I have measured the temperature of air coming from registers of furnace plants many times. I have often found it as high as 190 degrees to 195 degrees when the air was taken from the inside of the building. I think that it will require ordinarily, in a furnace heating plant, when the air is taken from outside at about zero, that the temperature of the air entering the room shall be about 140 degrees. If the air is taken from the inside of the building there will always be a little leakage past the damper between the outside and the furnace, so that the temperature of the air entering the furnace, even when it is taken from the outside of the building, will be rarely above 60 degrees; and this means that the temperature of the air as it enters the room will be in the neighborhood of 175 to 190.

Mr. Farquhar: I think I had better explain that our method is to keep the maximum temperature in zero weather at the register at 120 degrees. But as to the comparative temperature when using all outside air, that is what I want to know.

President Snow: Does the chair understand that 120 degrees would represent fair average practice using inside air?

Mr. Farquhar: Yes. Of course, that is with a combination of outside and inside air mixed.

Prof. Kinealy: My tests of furnaces show that it is very rare indeed that where a furnace plant is designed so that the air can be taken from the inside, that it is possible to heat the building in zero weather taking the air from the outside. I have found that ordinarily when we get down to the neighborhood of fifteen or twenty degrees, then we must take the air from the inside in order to heat the building without a very high temperature of the air entering the registers. That is what I have found where I have tested plants that were put in so that they could take the air either from the outside or the inside.

Mr. Chew: I will say it is a question how often you whirl the air around when you use the inside air of a building. John P. Schaffer said before this Society once that when inside air supply is used with a furnace plant that is designed to use outside air in the fall and spring and inside air in the winter time, there will be a very much more sluggish or very much slower movement of air from the register. I have not had any opportunity to know what you can do with inside air. All the plants that I have seen in operation have been taking the air entirely from the outside. Mr. Farquhar says he has a combination with inside and outside. Has that been your experience? When the air is taken from the outside you have a pretty lively movement from the registers. Now does that slow down when you do not have outside air and have inside air?

Mr. Farquhar: Yes, the action is a good deal stronger when you use the outside air and nothing to interfere.

Mr. Chew: What do you attribute that to, wind or weight?

Mr. Farquhar: It is the weight, I always supposed, yes. And when you use a combination of outside and inside air it becomes necessary to use large sized registers in order to give you the standard; that is, a relatively low temperature in the hot air pipe.

Mr. Chew: I want to go a little further on the question that the partition flue does not carry the amount of air that it should to do economical heating. If it is answered positively and properly it will mean that architects and others have got to plan

buildings a little differently, and that they cannot depend on a 3 x 4 or a 2 x 3-inch stud to give a sufficient partition space for a flue to let a furnace do its work with a fuel consumption that it would if it had deeper flues in connection with it. I believe that a man who has a narrow partition flue in his house is burning more coal than is necessary to heat that house comfortably if he had flues of round or nearly square shape. I hope the members will dig into that in the interest of the general public enough some day to tell me that the position I have taken on the subject is right. But I believe we are working in the right line when we are working for a departure from the universal type of tin partition flue used with furnaces to something that is deeper from front to back.

President Snow: There is an opportunity here for the furnace men to conduct a series of tests, as we have been told that the boiler men have done so, and very man knows what his boiler will do, so that the furnace manufacturers may discover the same information regarding their product.

TOPIC NO. 9.

"The Requirements as Regards Tightness that Should Be Met Where a Vacuum House Heating System Is to Be Installed."

Mr. G. D. Hoffman: Regarding the practice in the vacuum job, the first thing that I always think is necessary is to find the leaks. If the job does not hold vacuum there is a leak somewhere, and the great problem with the steamfitter in a case of that kind is to find the leak. Ordinarily speaking, I get up as much steam pressure as the safety valve will allow—if it is set for 15 pounds I will carry 14 pounds—and then search the entire job over, listening at every elbow and fitting and valve for a hissing sound that would indicate a leak of steam if we could not see it. I would go still further and look for vapor; because I had one job that I tested out down in North Carolina where with fifteen pounds of pressure on the job you could not detect the slightest sound anywhere, but right in connection with the diaphragm there showed a slight cloud of vapor. It was not distinguishable by sound at all. If you put your ear right against it you could not hear anything, but there was a little

vapor coming out. The man was unable to hold vacuum at all on the job for any period of time. I took that diaphragm off and put a plug in it and then made an eight-hour test on the job. I started at seven o'clock in the morning and at eight o'clock I had two pounds of steam, at ten o'clock I had twenty inches of vacuum; at four o'clock in the afternoon I had still nineteen inches of vacuum, having lost one inch in six hours of the test. Before starting the test I had hedged or I might say safeguarded both our own interest and the steamfitter's interest by stating to the owner that if we did not lose more than an inch an hour during the test that I would consider the job a practical working job. Fortunately for both of us we only lost one inch in six hours of the test.

I had another job that was a peculiarly and particularly bad one, in Wilmington, Delaware. We had tested and tested by the pressure test in every way that we could think of. And I will say in that connection that one of the best steamfitters in the country—not only in Delaware but in the country—was the man who installed that work. He was an exceedingly careful man. But we could not detect where the trouble was. Finally we got up pressure until the entire system was filled with steam, then turned off every radiator on the job and let it stand for about two hours, or until the radiators were entirely cold, maintaining at the same time a pressure equal to about atmosphere on the piping of the job. We then started in to turn every radiator on, one after another. The man who was turning the radiators on did it systematically and we, with a piece of chalk, marked on the wall when the gauge would jump. That man kept tab on the radiators and we kept tab on the gauge. In that job we found four radiators that would not halloo, as we expressed it; in other words, when the valve was opened that the steam did not rush into the radiator with a good deal of noise and commotion. We then began to hunt for the leaks in those four radiators and we found every leak in the job in those four radiators, and after those leaks were stopped the job went on working from 16 to 20 inches of vacuum and is still working to-day, entirely satisfactory to the owner.

In giving out our instructions for testing a low pressure vacuum job we tell the contractor to first test his job by a pressure test. If he finds that his job will hold fifteen inches of

vacuum for a period of several hours after the job is allowed to cool down—we make the test by getting up steam with a kindling fire and then allow the fire to go out—he passes it, but if that test does not prove satisfactory we then recommend the test that I have just described. I have never found an instance yet where we could not find the trouble and we generally found it in the radiators, sometimes so slight as not to be noticeable except on closest inspection—little sand holes or a leak in the screw nipple connections of the radiator. In one case I found where an air-valve tapping was cracked just below where the air-valve was put in, in such a way that it permitted a leakage to occur in that radiator. We had to ream out that tapping, bush the opening and then reconnect the valve in order to stop the leak in that particular radiator. After we did that we had no further trouble with the job.

Mr. Donnelly: I think that Mr. Hoffman's remarks have given us very valuable information. I have never heard them given before and never heard this test detailed; and it rather strikes me that perhaps it might be a good requirement, and it would not be very much trouble, if the radiator companies tested their radiators under a vacuum before they shipped them, now that the style of heating is being changed. They were all formerly used under pressure, but if all the radiators are to be used under vacuum the vacuum test at the factory would be desirable. Perhaps it may come along. But this systematic test of Mr. Hoffman is very interesting and I think it would be very valuable if Mr. Hoffman wrote it up at more length and gave it to us.

Mr. Davis: Mr. Donnelly speaks of radiator men testing their radiators under vacuum. That is all very well, but who will test them after they come in the courts?

Mr. Sparks: I would like to ask if there is any objection to testing radiators for heating systems by water. Now, if the system is filled full of water it will show leaks of any description. It will beat steam at 30 or 40 pounds. Water will leak through any kind of a space and show very readily under, say, a pound pressure of steam. I would like to know if there is any objection to that, if there is anybody that can raise any objection.

Mr. Shorb: I would like to give a little information on that line. He says water will show a leak that will show by any other

means. I am in the business of making air-tight tanks and I know it will not. We can test a tank with water and find it perfectly tight, and turn air into it and find it leaks at almost every rivet and all around the seams. So I do not believe in the water test.

Mr. Sparks: How much pressure do you test them with?

Mr. Shorb: 125 pounds.

Mr. Donnelly: I agree with the last gentleman that spoke. The air test is very, very severe. It is almost as severe as holding kerosene oil. And the only absolute way is to have all the air pressure inside, then to immerse the apparatus in water, then you get the air bubbles.

Mr. Shorb: Of course we cannot immerse a tank as large as we make in water, but we use soapsuds applied with a brush to give us the same result.

Mr. G. D. Hoffman: One of the objections to introducing water itself Mr. Sparks speaks of. It has been my experience that what we have to do is to make a test as simple as possible. If we are going to get the coöperation of the steamfitter he does not want to go to any extra trouble or any extra expense. Along the line that Mr. Donnelly suggested that I write something, I will say that I have written explicit instructions which are sent out with every part of our apparatus, and then we find the instructions lying all over the floor of the job. The steamfitter seldom reads them and seldom pays any attention to them until he gets into trouble. Then he halloos for help, particularly if the customer holds up his money. I had to make that trip to North Carolina just to take off that diaphragm and put on a perfect diaphragm so that the steamfitter could get his money. He never said a word until the man refused to pay him, and then he hurried and wrote, "Come down here and show me what the trouble is with your apparatus." But there was no trouble with the apparatus, the trouble was with the diaphragm on the boiler.

I have never advocated the water test for the reason that it simply adds to the complication of the job and tends to frighten the steamfitter against doing anything along the line of vacuum work. He is afraid enough of it as it is.

TOPIC NO. 10.

"The Guarantee that Should Be Given as to the Amount of Steam that May Pass Into the Returns in a Vacuum Return Line System of Heating."

Mr. Kauffman: I think that it all depends on what kind of system you are using, say the bleed valve system, or thermostatic basis or some system of that character.

Mr. G. D. Hoffman: Mr. President, there is no question but that an ideal appliance would be one that would close the instant steam reached the outlet valve, thus preventing steam from going into the line. But as the steamfitter is entirely dependent on the manufacturer of specialties to get up something of that kind, and as up to the present time there has never been anything of that kind made, consequently he lets the steam go into the line and it depends altogether upon the conscience of the steamfitter as to how much steam he permits to go to waste. The more steam he permits to go to waste the surer his job will heat, but waste steam means waste coal.

Mr. Donnelly: Mr. Hoffman stated that the most desirable appliance was one which passed no steam into the return. In ninety-nine cases out of a hundred I do not agree with that statement. If the returns are to run a long distance under ground, where the rise of heat would be considerable from the return, I think it happens very, very seldom. In the majority of cases the return is boxed in in the same box with the steam main, and consequently the steam line would keep the return pipe hot; in any case it would keep the conduit hot. In ninety-nine installations out of a hundred such as this there is no objection to steam in the return line. If in a gravity plant the specification said two pounds of steam, there would be no objection to steam in the return, as they expected the steam to run back into the boiler at say a pound and a half or three-quarters. The steam in the return line serves to keep the water hot. You have got to keep it warm in a gravity plant. I see no objection to keeping it to the vacuum temperature, and as a matter of fact this steam fed into the return serves to supply a radiator effect to the return and keep the water warm. If it were not done it would have to be reheated on coming back to the boiler. So that in any case the difference in amount of steam to maintain this temperature or reheat it afterwards would be very much

the same. In a plant where a certain vacuum is specified from the return line it would be very undesirable for the engineer to specify an unusually high vacuum where it would be impossible to produce it or maintain it without putting considerable heating surface on the return, without heating large quantities of water for the return, or automatic or other apparatus from the return feeder or without using excessive quantities of jet water. So far as I know, these figures are reasonably accurate.

There is one thing I do not know at the present time, and that is exactly the temperature of return water as it leaves the radiator, as it goes through the automatic appliances upon the radiator or somewhere else on the plant. I do not think the water is exactly the temperature of the steam. When you realize how difficult it is in an open top feed-water heater, where the conditions are made very strong to get the water if possible up to the temperature of the steam, and in spite of that we do not in open feed-water heater work get exactly the same temperature as the steam. We, however, consider that the condensation flowing along the bottom of the return pipe, with the steam above it, would be proof that the water is about the temperature of the steam. I am going to try to make some experiments with thermometers and find out the temperature of the water. I really believe that it is considerably lower in many cases. I am led to that belief because in some plants I have experimented with I have found that it is possible to maintain a lower vacuum than figures would show. Now, in a plant specified as ten inches of vacuum, it will take just about two per cent. of the radiating surface of the building to cool the water in condensation; that is, two per cent. condensing effect. Of course, as the condensing effect of the surface goes down by reason of the temperature going down, the figures show with twenty inches of vacuum, eight per cent. of the surface of the plant is required upon the returns. You simply take the re-evaporation, condense the re-evaporation to cool the water, which runs surprisingly high when we get the high vacuums, because the temperature goes down very fast.

Mr. G. D. Hoffman: I would like to correct a false impression that Mr. Donnelly got from my remarks, that it was not a good thing to allow any steam to escape into the line. My thought was on the ball system line rather than on the return line.

President Snow: That is on simply an air line system?

Mr. G. D. Hoffman. An air line system, yes.

Mr. Feldman: Mr. Donnelly spoke about high vacuums. I think the time of high vacuums has gone by. If you can get a circulation with one or two inches of vacuum there is no necessity of getting 24 inches. In a New York hotel twelve stories high I use only a two-inch vacuum and get excellent circulation. There is also a twenty-story building, in which a circulation is obtained with a two-inch vacuum.

President Snow: Are there any further remarks as to the guarantee that should be given? That was the main point here, as to what guarantee should be given as to the amount of steam passed.

Mr. Davis: It would seem to me that the condition of the apparatus itself must govern that to a great extent. If the volume of exhaust steam that is being produced is greater than that that is being used for the heating system, then the amount of jet water used is a matter of indifference. But if the amount of exhaust steam that is being produced is less than is being condensed, then the jet water is a serious matter.

Mr. Donnelly: I would like to state in answer to Mr. Davis that I have met that condition very many times. I found that when the plants considered the Sunday running and night running, and the exhaust was not available, that that was the very time that the jet water was very objectionable, that then they were condensing live steam with jet water and throwing it into the sewer, which was very objectionable.

I might say in regard to that that there are very few plants laid out that have less than ten per cent. surface on their return. Their ordinary vacuums are very easily produced.

I would like to ask from Mr. Davis, information as to the maximum amounts of steam that were passed into the returns in some of the more ancient and obsolete vacuum return line systems, such as the opening of restricted dimensions, and vulcanite plugs, that have gone out of use to a considerable extent. What did Mr. Davis consider in his experience of that time, and whether occasionally 25 to 40 per cent. of steam did not by some means get into the return mains.

Mr. Davis: With a well designed controlling device on the return line, properly adjusted, the amount of steam passing into

the return line is not objectionable. But the trouble has been with a device of that kind if it was tampered with. Very often my experience was that we would get a job well adjusted, working properly, no more steam going into the return main than was necessary to produce good circulation, and in forty-eight hours were put out of commission by being tampered with. Of course there are and were various classes and types of return line valves that do not operate properly, and in consequence there were many times when there was an objectionable amount of steam going into the return line.

MEMBERSHIP OF THE SOCIETY.

JANUARY, 1910.

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Newton, Chas. W., 1202 W. Fayette St.....Baltimore, Md.

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Hellerman, Harry H., 312 Cherry St.....Philadelphia, Pa.
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Hill, Norman A., 1503 Sansom St.....Philadelphia, Pa.
Hoffman, Geo. D., 282 Michigan Ave.....Chicago, Ill.
Hoffman, Prof. J. D., Purdue University (Pres. 1910),
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Kellogg, Albert T.....Kewanee, Ill.
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Kansas City, Mo.
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Smith, H. A., Hartland.....Niagara Co., N. Y.
Snow, Wm. G., 24 Milk St. (Pres. 1909).....Boston, Mass.
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Soule, Lawrence C., 282 Michigan Ave.....Chicago, Ill.
Speller, Frank N., 1828 Frick Bldg.....Pittsburg, Pa.
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Zeck, Alex. .....Grafton, W. Va.

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Sharp, Frank D.....State College, Pa.
Tjersland, Alf., care E. Sunde & Co.....Christiania, Norway

Thomas J. Waters

WHEREAS, the painful intelligence has been conveyed to The American Society of Heating and Ventilating Engineers of the decease of one of its members, Mr. Thomas J. Waters, of Chicago, Ill., which occurred on February 25, 1909.

Resolved, That in this bereavement we recognize the hand of the Omnipotent, and while we submissively bow to His will, we would record our sense of profound sorrow which as individuals, and as members of this Society, we experience in his loss to us and to the cause which he served with honor and distinction.

Resolved, That as a member he has commanded our respect for his superior abilities and his zealous application of them to every duty.

Resolved, That the exhibit of his work through the Society at the Paris Exposition in 1900 brought credit alike to himself and the Society.

Resolved, That we bear testimony to the cordial relations entertained by him and which his uniform courtesy inspired among the members of the Society, and to his efficient labors amongst them in all things pertaining to the welfare, progress and aims of the Society of which he was a charter member, the organization of the Illinois chapter of the Society being largely due to his efforts.

Resolved, That we recognize the indomitable energy of his nature, his sterling integrity and the marked ability which enabled him to attain the eminence in his profession which he held, demanding due acknowledgment both in this Society and in public life.

Resolved, That these resolutions be entered in full on the Minutes and that the Secretary be instructed to forward a copy, suitably engrossed and signed, to the family of our late associate.

NEW YORK, June 25, 1909.

WM. G. SNOW,
President.

W. M. MACKAY,
Secretary.

In Memoriam

	Became a Member	Died
L. H. Hart, New York	Sept. 1894,	Jan. 26, 1897
James W. Gifford, Attleboro, Mass.	Jan. 1898,	July 26, 1899
William McMannis, New York	Sept. 1894,	Jan. 19, 1901
Charles F. Tay, San Francisco, Cal.	Jan. 1896,	Sept. 8, 1901
Arthur H. Fowler, Philadelphia, Pa.	Jan. 1897,	June 3, 1903
Stephen G. Clark, New York	Dec. 1902,	Feb. 3, 1904
Charles M. Wilkes, Chicago, Ill.	Jan. 1897,	Jan. 7, 1905
James Curran, New York	Dec. 1901,	Oct. 27, 1905
Herbert W. Nowell, New York	June 1904,	Mar. 25, 1906
Enoch Rutzler, New York	July 1901,	Feb. 29, 1908
Harry J. Ott, Chicago, Ill.	Dec. 1906,	Sept. 25, 1908
Thomas J. Waters, Chicago, Ill.	Sept. 1894,	Feb. 25, 1909
Max J. Mulhall, New York	June 1909,	July 30, 1909

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